THE IMPACT OF SUBCONTRACTOR USE ON PERFORMANCE IN CIVIL CONSTRUCTION: LEARNING FROM A POST-EARTHQUAKE INFRASTRUCTURE REBUILD ALLIANCE

A research thesis submitted in part fulfilment of the degree requirements for the Degree of Masters of Engineering in Construction Management

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ABSTRACT

Principal contractors can achieve better financial performance in civil construction projects by increasing the proportion of works delivered by subcontractors. However, anecdotally the use of subcontractors is thought to be make principal contractors less competitive due to compounding profit margins. This study found that projects with a higher proportion of subcontracted work exhibit better financial results than projects with less work delivered by subcontractors.

This study uses the Christchurch Infrastructure Alliance (known as the Stronger Christchurch Infrastructure Rebuild Team, SCIRT) as a case study to observe why principal contracting firms engage subcontractors and the effect subcontracting has on the overall performance of a construction project.

Five top tier civil contracting firms (known as 'delivery teams') participated in the alliance. Each team was responsible for the delivery of individual projects. A sample of 334 individual SCIRT projects were analysed, and key delivery team staff were surveyed, to investigate the effect subcontractor engagement has on performance.

Between the five delivery teams there were clear differences in how much work was delivered via subcontracts. The extent of this subcontractor engagement had a significant effect on the relative performance of the principal contractor. A positive correlation between subcontractor engagement and overall financial performance is observed, and a negative correlation is observed between subcontractor engagement and non-financial performance.

Although the causes of these relationships appear complex, the primary reason appears to be that subcontracting fosters increased productivity by cascading financial performance incentives closer to the physical construction task. To maximise competitiveness and financial performance, principal contractors must embrace the use of subcontractors and develop efficient systems of managing subcontracted work.

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1. INTRODUCTION

This thesis starts with examining the context of the New Zealand infrastructure industry, and the local opportunities presented to construction contractors. Following this, a research topic and objectives are defined and justified.

1.1. Context and background

Spending on capital projects and national infrastructure in New Zealand is expected to increase at an average rate of 4% annually to $28 billion by 2025 (Oxford Economics, 2014). The New Zealand government has identified current relative economic prosperity as a window of opportunity to ensure the country's longer term international competitiveness. Vital to this, is increasing the capacity of civil infrastructure networks to provide the foundation of a strong, competitive economy.

In 2015, the New Zealand Treasury forecast that $110 billion will be spent on infrastructure during the 10 years from 2015-2025 (National Infrastructure Unit, 2015). The National Infrastructure plan (2015), identifies among other issues, the need to use more sophisticated methods of procurement to ensure the year 2045 target of having a supply of *"infrastructure that is resilient, coordinated and contributing to a strong economy and high living standards"* (National Infrastructure Unit, 2015, p. 46). It is expected that relational procurement strategies that aggregate works and increase the magnitude of projects and services will be favoured to reduce overhead losses and increase efficiencies of scale (National Infrastructure Unit, 2015). Contracting companies need to prepare themselves to deliver projects in the most efficient manner, in order to maintain local competitiveness in the construction market and increase the benefit of infrastructure investment for the country.

With an increase in relational style contracts in the industry, there will be an inevitable shift away from client-led delivery strategies. This presents an increasing opportunity for lead contractors to develop project delivery methods that increase their competitiveness and profitability in the New Zealand market.

1.2. Statement of research problem

Currently, the choice of project delivery method used by top tier contractors in the New Zealand civil construction market is not well represented in academic literature. Discussions of the effect and utilisation of subcontracts by principal contractors to deliver portions of the physical works are largely absent.

Despite this absence, evidence in the industry suggests the prime motivations to utilise such subcontracts are well known and understood at the executive level of principal contracting companies. However, in the homogeneous environment presented by the SCIRT alliance contract, there is evidence of fundamental differences in subcontractor engagement between the principal delivery contractors. Furthermore, there are suggestions within the industry that some principal contractors believe that engaging subcontractors on a large scale decreases the principal's profitability and competitiveness. This belief has not been subject to the rigours of academic scrutiny, and is therefore questionable and requires investigation.

The impending increase in infrastructure spending in the New Zealand construction market, and likely change in procurement strategy to favour relational contracts, presents an opportunity for contractors to define a subcontracting strategy that will serve to maximise their competitiveness and profitability.

On 4 September 2010 a 7.3 magnitude earthquake struck Christchurch City, causing significant damage to the city's infrastructure. Following this, and subsequent earthquakes an alliance contract to rebuild the damaged horizontal infrastructure was implemented. This Alliance has become known as SCIRT (The Stronger Christchurch Infrastructure Rebuild Team) (Christchurch Infrastructure Alliance, 2011). The nature of this alliance contract presents an opportunity to review and compare the subcontracting strategies of the alliance participants in a homogeneous environment.

1.3. Research Aim and Objectives

This research aims to identify and evaluate the differing motivations and commercial strategies surrounding the engagement of subcontractors by principal contractors in civil construction.

This work will analyse the situation that has unfolded in SCIRT and provide learnings to the civil contracting industry that may increase productivity and efficiency in future large scale disaster recovery or capital improvement projects.

SCIRT has committed to developing a repository of information and learnings gained in the rebuild process, this project is referred to as the 'SCIRT Learning Legacy'. The research objectives of this thesis align directly with the Learning Legacy purpose of "exploring and implementing smarter and more effective ways of providing infrastructure solutions to New Zealand and the international community" (SCIRT Learning Legacy, 2014).

The research questions below provide direction to the formulation of the research strategy and methods of data collection;

1. Why do principal contractors subcontract sections of work?
2. What different strategies do principal contractors employ for subcontracting works?
3. Does the extent of subcontractor engagement have an effect on financial or non-cost performance?

1.4. Scope and Limitations

This research uses data from the SCIRT alliance. Therefore, its scope is limited to the observations of the SCIRT alliance between September 2011 and May 2016. The sample of projects used in the study was limited to the availability and completeness of the project data.

The study compares and contrasts the performance and strategy of the five delivery teams within SCIRT. It follows then, that the study is limited in some cases to five data points – which for trend analysis is a small sample.

There is a reliance on self-reported data in the study, in both the primary and secondary data sources. This exposes the findings to the inherent limitations of self-reported data. These limitations include, but are not limited to: selective memory; telescoping; attribution and exaggeration. However, the use of self-reported data in studies of civil construction is supported by Rankin, Fayek, Meade, Haas, & Manseau (2008) in their study measuring performance of the Canadian construction industry. Further, Toole & Abowitz (2010) defend the use of self-reported

data in construction and assert that its validity and reliability can be improved by combining quantitative and qualitative approaches to the research.

1.5. Importance of Research Findings

The research findings are of particular importance to the civil construction industry. Understanding the relationship between subcontractor utilisation and financial performance of projects will allow project managers and company executives to make informed strategic decisions around the level of subcontracting employed in distinct projects. Optimising performance is critical to ensuring the competitiveness of a firm.

1.6. Structure of the Thesis

The thesis is structured in four main parts:

1. Literature review,
2. Methodology,
3. Data presentation and Analysis
4. Discussion and conclusion.

Firstly, a review of the literature is carried out which explores on the current knowledge for subcontracting in civil construction. Following this a study methodology that will allow the investigation of the research questions is designed and tested.

Mixed method research is employed for this study which utilises two sets of data. One set is qualitative in nature (collected via interviews), and one set is quantitative (originating from recorded observations). Each set of data is first described in detail and defined, then the respective results are presented analysed.

The thesis is concluded with a discussion of the results and the development of conclusions from these findings.

2. LITERATURE REVIEW

2.1. A definition of subcontracting

Subcontracting is defined by Pagnani (1989) as a legal–economic relationship between two agents, in which the characteristic criteria are substitution and subordination. Substitution implies that the subcontractor subsumes the technical and financial risk involved in the operation, while subordination denotes that the subcontractor must follow the direction given by the principal Shimizu & Cardoso (2002). This type of relationship, where principal and subcontractor motivations seem to be at odds, can be strained. It therefore follows that subcontracting creates opportunities and issues for all parties involved (Table 1 , taken from (Shimizu & Cardoso, 2002)).

Table 1: Aspects of subcontracting in the construction industry (Shimizu & Cardoso, 2002).

Aspects	Comments
Flexibility	Subcontracting appears as an answer to market uncertainties
Quality	Subcontracting, on the one hand, can improve product quality because it uses specialized man power and, on the other hand, can get worse, because it leads to problems of control and coordination.
Costs	Fixed costs become smaller, while transaction costs increase. Fixed cost are lesser because subcontracting eliminates equipment maintenance and underutilised manpower. Transaction coast can become bigger, because each new contract negotiation can involve some proposals by subcontractors.
Productivity	Subcontracting tends to further tie the labourer to the firm subcontractor. Thus, the effects of replication, continuity and learning lead to higher productivity by the manpower. Easy access to specialised equipment and constant training also lead to higher productivity.
Controls	Controlling the quality of work is difficult with subtracting, because the high amount of independent organisations in the site makes the control of work progress difficult.
Planning	The intensive subcontracting of manpower makes the planning process difficult. Moreover, conflicting interest can intervene negatively with the programming of activities.
Technology	Market instability leads the contracting firms not to establish stable agreements with the subcontractors, thus not allowing technology transfer.
Training	The contractors tend to pass the responsibility of training to the subcontractors, but generally they are not apt to accomplish it, due to financial features and the lack of time for training.
Safety at work	The final responsibility for the safety at work falls on the contracting company, as we as the implementation of a safety programme, the commitment and supervision of the subcontractors. The disinterest of the contract in investing in programmes of safety for floating and unknown workers and the lack of familiarity of the workers with the working atmosphere aggravates this problem.
Consumption of materials	Subcontracting can magnify materials waste; subcontractors tend to finish the job as fast as possible, without controlling the use of materials.

The logic that specialisation drives increased productivity is simple in its ideals, by dividing work tasks into distinct elements, skill requirements are narrowed and costs will therefore decrease. This system effectively reduces the subcontractors control over the final product. However, the subcontractor retains a considerable degree of control over certain aspects of the labour process, for example, the specific way in which a task is carried out, the pace of work and the level

supervision (Marglin, 1974). Therefore, in a system of specialised subcontractors, each remains able affect their productivity and quality outputs, despite losing the ability to control the final project deliverables.

Today, in the construction industry, project managers from principal contracting companies often engage numerous specialty sub-contractors who, collectively, will perform the majority of the work in the contract (Sacks & Harel, 2006). In some cases, the entire physical works of a project will be completed by subcontractors, with the principal acting in a supervisory/project management capacity only.

2.2. Subcontracting in construction

The extent to which principal contractors operating in the construction industry rely on subcontractors and material suppliers for the successful delivery of contracts is well understood (Shimizu & Cardoso, 2002; Hinze & Tracey, 1994; Sacks & Harel, 2006; Eom, Kim, & Jang, 2015). The prevailing reasoning for this reliance is threefold (Ng & Skitmore, 2014; Nobbs, 1993; Elazouni & Metwally, 2000);

1. **Ability** -Subcontractors possess specialist trade skills, or have access to specialist machinery required;
2. **Flexibility**- Subcontractors have flexible capacity to meet the changing labour demands of a particular project and,
3. **Cost**- specialist subcontractors are often able to perform distinct tasks at a cheaper rate, or by using subcontractors project managers attain overall cost certainty around aspects of the project.

With these motivations, the use of subcontractors remains a popular alternative to self-performing construction tasks. Since the mid-1900s principal contracting firms have progressively decentralised, as subcontracting became a key element of their businesses (Beardsworth, Keil, Bresnen, & Bryman, 1988).

Notwithstanding the aforementioned importance of subcontracting in construction, as Eom et al. (2015) highlights, analysis of the relationship between principals and subcontractors is largely absent from literature. Hinze and Tracy (1994), and Arditi and Chotibhongs (2005) investigated these relationships from the subcontractors side, and discussed point in time industry-wide

contractual issues. But the conclusions of these studies are limited in how they may be applied across differing contractual environments.

2.3. Traditional short-term principal-subcontractor relationships

In the majority of cases, subcontractors operate in a market of comparable service providers, akin to a commodity market where they are one of a pool of suppliers. Therefore, it seems logical that in such an environment, subcontractor engagement and selection on part of the principal is a simple process. In this environment, principals will go to the market and select the lowest priced subcontractor with a conforming service – this is referred to as bid shopping (Hinze & Tracey, 1994; Arditi & Chotibhongs, 2005). With good contractual arrangements and management, this method is an effect means of subcontractor engagement.

This type of contractor selection tends to necessitate a heavy handed approach to subcontractor management by principal contractors. After a period of extensive bid shopping, sub-principal relationships tend to be adversarial in nature with a greater amount of distrust between the parties (Hinze & Tracey, 1994). Principals utilising this approach tend to employ intense contract supervision and management to ensure that quality, safety and environmental obligations are met by the subcontractor. While the subcontractor pushes hard to maintain or exceed productivity targets in order to increase margins. Tensions in these environments are high, characterised by distrust and a lack of communication between parties.

2.4. Relational contracting

Globally, the use of procurement strategies which improve the efficiency and the effectiveness of civil construction projects are increasing (Scheepbouwer & Humphries, 2011). The complete procurement cycle is seen as one project which involves several key players, including the owner, designer, contractor, subcontractor and suppliers (Cheung, Yiu, & Chim, 2006). Relational contracts acknowledge this, and recognise the success of a project is dependent on the collective ability of the team designing and building it (Asmar, Hanna, & Chang, 2009).

Single-stage procurement, in which the main contractor is appointed only in construction phase, shapes the relation between the parties at a stage where equality is not given (Rahmani, Khlfan, & Maqsood, 2013). Instead, in this approach it can be assumed that both parties are trying to

maximize their own interests as much as possible. In this situation, a wholehearted cooperation is assumed to be difficult, unless a supportive contractual framework is put in place. Thus, in order to ensure a "win–win" environment, the selection of contract types is one of the key determinants of success (Cheung, Yiu, & Chim, 2006). The contract itself is a projection into the future and involves present communication of a commitment to a future event (Kumaraswamy, Rahman, Ling, & Phng, 2005). In this context, partnering is believed to represent a possible means of addressing the problems of adversarial relationships, mistrust, and inefficient communication in the construction industry (Cheung, Yiu, & Chim, 2006). Relational contracting or relationship contracting arrangements aim to minimise disputes by recognising and developing common interests among contracting parties (Koolwijk, 2006).

Where traditional contracts attempt to enforce and hold contractors to their obligations, partnering and relational style contracting incentivise more collaborative solutions, where benefits are shared. An alliance agreement where all participants share in the success or failure of a project, acts as an effective financial incentive to find quick, amicable solutions to any disputes that may arise.

However, it is noted that examples of litigious disputes between parties involved in relational contracting are most often groups acting on the periphery of relational contracts such as subcontractors and suppliers who are vulnerable as unsecured creditors (Ramachandra & Rotim, 2015). These parties are not protected from disputes like those acting within the relational contract. A litigious dispute is still possible, and probable, with suppliers and subcontractors whose goods/services are crucial to the project but are not legally participating within the relational contracts. In some cases a traditional contract, established to service the interests of the relational contract, may be subject to the same issues of dispute that the original contract sought to avoid. In effect, the risk of dispute and litigation cascade down, rather than the issue being mitigated outright.

2.5. Relational Changes in subcontractor engagement

As discussed above, in specialities where the subcontract market for a service is ubiquitous, Principal-Subcontractor relationships have in large part been characterised by traditional short term authoritarian and adversarial engagements. However, recent studies assert that changes

within the global business environment have shifted subcontracting toward a more advanced principal of partnership (Eom, Kim, & Jang, 2015).

Eom, Kim, & Jang (2015) state that there is a growing movement toward partnering in Principal-Subcontractor engagement , perhaps to mitigate the cascaded risk of disputes and the associated inefficiencies and negative impacts of such. Eom, Kim, & Jang (2015) identified seven partnering elements understood by the industry to be of critical importance in an effective partnering relationship;

1. Subcontracting strategy,
2. Performance improvement,
3. Process innovation,
4. Information sharing,
5. Cooperation in collaboration,
6. Standardization of selection,
7. Feedback of evaluation.

Although, the results of their research suggest that these elements, while known, are currently lacking in execution within the industry.

2.6. The SCIRT Alliance Contract

The Stronger Christchurch Rebuild Team (SCIRT) is a complex alliance agreement between eight separate participants. It was formed with the purpose of rapidly repairing Christchurch City's horizontal infrastructure after a series of damaging earthquakes.

2.6.1. Context of the alliance

On 4 September 2010 a 7.3 magnitude earthquake struck Christchurch City, causing significant damage to the city's infrastructure. In response to this event, the Christchurch City Council (CCC) set up the Infrastructure Rebuild Management Office (IRMO), an internal division to facilitate the reinstatement of key council assets (Provost, 2013).

The IRMO identified key areas of damage to CCC assets, and entered into four design-build contracts via a competitive tender, to rebuild these areas. The four successful tenderers were:

- Fulton Hogan Ltd.
- Downer New Zealand Ltd.
- City Care Limited

- Fletcher Construction Ltd. and McConnell Dowell Constructors joint-venture

On 22 February 2011 the situation changed, when another earthquake struck Christchurch just 10km from the central city. The second earthquake caused more extensive damage than the first, and CCC soon recognised that the arrangement it had under the IRMO was no longer appropriate for the larger scale of the task (Provost, 2013).

In April 2011, the Canterbury Earthquake Recovery Act was passed by the New Zealand Government and the Canterbury Earthquake Recovery Authority (CERA) was formed (Parlimentary Counsel Office, 2011; Brownlee, 2011). CERA, in collaboration with the New Zealand Transport Agency and CCC, reviewed various procurement options for the rebuild of Christchurch and decided that an alliance contracting approach would deliver the best outcome.
By the time an alliance model was proposed, the four contractors working under the IRMO arrangement had already begun physical works in their areas (Provost, 2013). Due to this, it was agreed that these existing contractors (with the separation of the Fletcher Construction and McConnell Dowell joint-venture) would be incorporated as non-owner participants (delivery teams) in the new alliance.

The five contractors formed an unincorporated joint venture to respond to the proposal, and in September 2011 the Stronger Christchurch Infrastructure Rebuild Team (The SCIRT Alliance) was formed (Christchurch Infrastructure Alliance , 2011).

2.6.2. The SCIRT Alliance as a homogeneous environment for research

The SCIRT alliance presents a unique environment where the five delivery teams are operating in the same environment - each carrying out very similar work under the same delivery contract. This situation affords the opportunity to analyse the differing strategies of the delivery teams in a controlled environment.

2.6.3. Project Definition Within SCIRT

Within the SCIRT Alliance, delivery teams are allocated distinct projects from the Integrated Services Team (IST). Prior to allocation, the IST follows a structured management plan to deliver projects from definition and prioritisation through to project completion through a series of stages called ‘gates’(Figure 1, page 11). These gates, as defined by the Auditor General (2013) , are described in more detail in Table 2 (pg. 11).

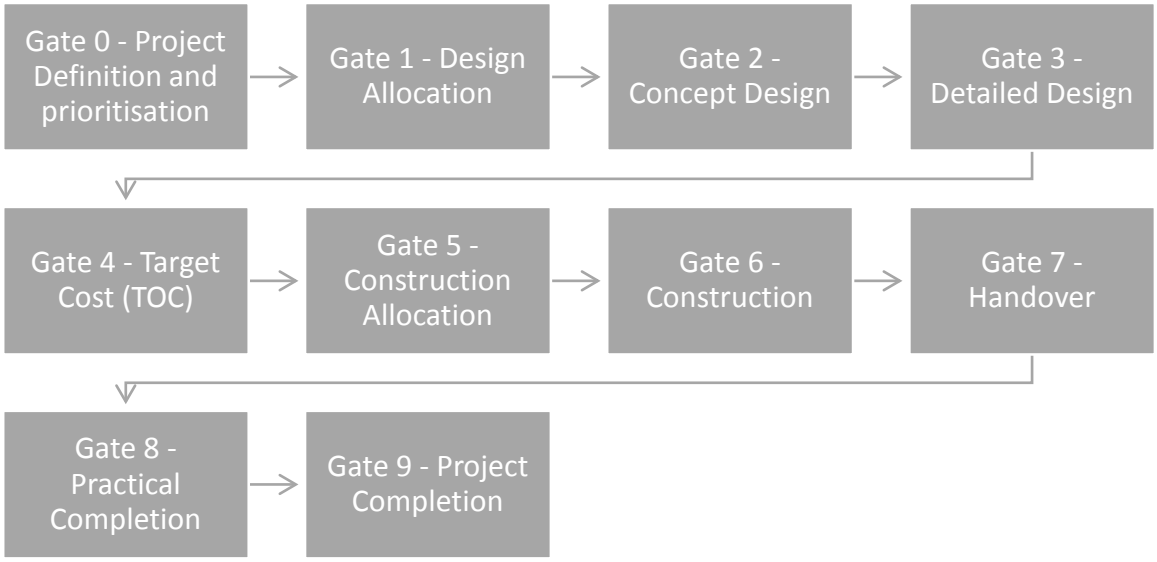

Figure 1: Delivery process of SCIRT Projects

Table 2: Description of SCIRT project delivery gates

Gate	Name	Description
0	Project Definition and prioritisation:	Project scoping utilises hydraulic wastewater and storm water catchments, network interdependencies and proximity considerations to group work sections. Repairs are aggregated so where possible an optimum project value of $10 million is achieved, however if no interdependencies or efficiencies are to be gained individual projects of less that this are created.
1	Design Allocation:	Once scoped, the project is allocated to one of four design teams. The design teams are made up of staff seconded from alliance partner and external organisations.
2	Concept Design	In collaboration primarily with the asset owners, concept catchment design solutions are proposed.
3	Detailed Design	Constructability guidance is supplied by the delivery teams through early contractor involvement. This, along with layers of review and internal and external consultation ensure the best detailed design is reached.
4	Target Cost (TOC)	SCIRT Estimators, independent of the non-owner participants, use a master pricing schedule (which is audited by external parties) to build the target cost of a project. Risk is allowed for in the TOC by way of a risk register, which is periodically released as construction progresses. The auditor general commissioned a further independent review of the TOC estimation process and found that "When relevant variables are considered" (ground conditions, local construction market and complexity) "SCIRT projects seem reasonably priced" (Provost, 2013, p. 46)
5	Construction Allocation	The allocation of a project to a delivery team is a part of the system of measures that seek to incentivise competition between the delivery teams in an effort to maximise the associated efficiency gains. Construction allocation hinges on the calculation of a DPS (Delivery Performance Score) which determines the percentage of work to be assigned to a team (Target allocation). The DPS is a measure of cost and non-cost performance in current projects. The initial target allocation was set to 20% until enough performance data could be gathered to start differential allocation. Non-cost performance is measured against the KRA framework, this is described in detail in section 2.6.5, page 13.

6	Construction	Once a project enters the construction phase it is up to the delivery team to deliver the works. During this phase KRAs are monitored through regular audits and other means.
7	Handover	Once the physical works are complete, delivery teams must collate all relevant quality assurance and construction documentation for the project and present it to the IST for review. Site inspection with asset owner's representatives must be complete and any significant defects may push the project back into the construction phase.
8	Practical Completion	Once the requirements of the handover stage are complete and the there are no significant construction defects, the projects enters a 12 month period, similar to a defects and liabilities period, in which and issues due to design or construction that arise are dealt with by the SCIRT team. During this period, normal maintenance and operational issues are dealt with by the asset owner.
9	Project Completion	12 months after Practical completion is achieved the assets are completely handed back to the owner.

2.6.4. Project Payments in SCIRT

Delivery teams receive payment for projects under a three-limb commercial framework, with Limb 1 a reimbursement of actual costs, Limb 2 a profit and corporate overhead margin on the target cost, and Limb 3 being a lump sum payment or penalty determined by achievement against financial and service performance measures at the completion of the alliance(Table 3, pg.13).

The profit/overhead component of the payment framework is fixed as a proportion of the TOC allowance. Therefore, where project scope changes occur Delivery teams are motivated to seek a variation to the TOC value to ensure the correct Limb 2 and 3 payments are allocated.

Table 3: Three limb commercial payment framework for delivery teams within SCIRT

Limb	Description
1	The total of the actual costs of the project claimed by the delivery team. It includes costs such as labour, plant, materials, transport, site facilities, communication, and advertising. It does not include any off-site overheads or profit. All costs are coded and reported to show that they have been allocated correctly, and an independent audit provides assurance to the three public entities that rates and expenses charged to the project are as defined in the Alliance Agreement.
2	Paid as a fixed lump sum to cover profit and corporate overheads. It is a set margin. For projects, this is calculated by applying the margin to the Limb 1 costs of the target cost (not the actual costs) incurred by the delivery team under Limb 1 for the project. Once the target cost is set, the amount paid under Limb 2 does not change unless there is an approved variation to the target cost.
3	An incentive payment or cost determined by both financial and service performance. If the actual cost of a project is less than the target cost, a 'gain' is created. If actual costs are greater than the target cost, 'pain' is created. Limb 3 payments are lumped into a final programme completion to be paid by the relevant alliance participants at the completion of the SCIRT programme (Christchurch Infrastructure Alliance , 2011). Financial performance is measured by comparing the final actual costs (FAC) of a project against its final target cost (FTC). Service performance is measured as the Overall Performance Score (OPS) which is a maximum score of 100 measured against the Key Result Areas (KRAs) (Table 4). • FAC: Final Actual Cost • FTC: Final Target Outurn Cost • OPS: Overall Performance Score To establish an approximate value for the PM11 project an OPS of 75 has been assumed. Limb 3 is calculated as follows: $(\text{FAC-FTC}) \times (0.5 - (0.1 \times (\text{OPS-50})50))$

2.6.5. SCIRT KRA framework and subcontracting bottom line.

The Alliance agreement (2011) defines the requirements for management of the Key Result Areas (KRA). This management plan is used to measure delivery team performance in areas aside from cost that have been identified as important to the three non-owner participants. KRAs are monitored and contribute toward two key performance scores (Provost, 2013):

- The Delivery Performance Score (DPS) is generated for each delivery team. The DPS collates performance against the KRA's and performance against TOC to determine the amount of future work allocated to each delivery team.
- An Overall Performance Score (OPS) is generated across the delivery teams to represent the overall delivery performance supplied to the Non-owner participants. The OPS contributes to the calculation of the limb 3 payment (pain/gain share).

The KRA framework is separated into five areas; safety, value, our team, customer satisfaction and environment (Table 4). Weightings between these areas differ to reflect the impact that each have on the development of OPS. With the exception of the Safety area, which has not been given a weighting, emphasising the importance of a zero harm culture that is not enticed, but is seen to be a basic requirement of each alliance member (Wilkinson, Kempton, & Gleeson, 2012).

Table 4: SCIRT Key Performance Indicator framework

Key Result Indicator	Weighting	Key Performance Indicator
Safety	0%	Safety Engagement- Awareness
		Safety Initiatives - Action
Value	35%	Productivity Gains
		Quality
		Innovations
Our Team	20%	Alignments & Team Involvement
		Health and Wellbeing
		Ownership of a skilled workforce
Customer Satisfaction	30%	Satisfaction Product
		Satisfaction with communication
Environment	15%	Construction
		Waste Minimisation

There were a number of significant changes to the KRA framework over the course of the SCIRT programme, these changes include the introduction of different Key Performance Indicators (KPIs), and manipulation of weightings on existing KPIs. Changes were made to respond to the need to re-calibrate and maintain a consistent focus on continuous improvements in non-cost performance areas (Gibb & Cameron, 2014). The reporting bands for all KRIs and component KPIs were also subject to regular review to foster continuous improvement.

2.6.6. Subcontracting in SCIRT

A minimum level of subcontractor engagement is set in the alliance agreement with the aim of fostering a competitive and skilled workforce at the conclusion of the alliance. A minimum of 40% of the work completed, by cost, must be subcontracted (Christchurch Infrastructure Alliance , 2011). A process must be followed to select subcontractors in a competitive and transparent manner. The delivery teams are then responsible for ensuring that subcontractors meet the same standards of operation and key result area (KRA) reporting that they do (Provost, 2013).

2.6.7. Changes to design guidelines over the SCIRT programme.

As SCIRT became responsible for the repair of damaged horizontal infrastructure, it was clear that a set of new innovative and efficient design standards would be required. In response to this, the Christchurch City Council developed what they called the Infrastructure Recovery Technical Standards and Guidelines (IRTSG) (Botha & Scheepbouwer, 2016) (Provost, 2013). These guidelines facilitated an immediate response to the most critical repairs. However, over the course of the SCIRT programme the IRTSG design guidelines were modified and developed as the needs of the network and constraints of working in a posts disaster context were better understood. Scheepbouwer & Botha (2016) catalogued these changes, their purpose and evolution. Three revisions to the original IRTSG design guidelines have been issued to date; Design Guideline 43

(DG43) was adopted in October 2013 and in July 2014 DG43-B was adopted, and in August 2014 DG43A-1 was also adopted (Trout, 2015) (Figure 2).

Initially, the IRTSG stipulated rapid repairs, while the subsequent design standards were less likely to be class damage as earthquake related. To this end, DG43 deferred all repairs of defects in the pipe network with a remaining asset lifespan over 15 years (Heiler, Moore, & Gibson, 2012) as cited by (Botha & Scheepbouwer, 2016). This Design Guideline was utilised to design and construct approximately 30% of the repair programme (Trout, 2015). DG43 B and A1 further reduced the scope of repairs that would be carried out under SCIRT – by effectively reducing the lifespan threshold to 5 years (Trout, 2015).

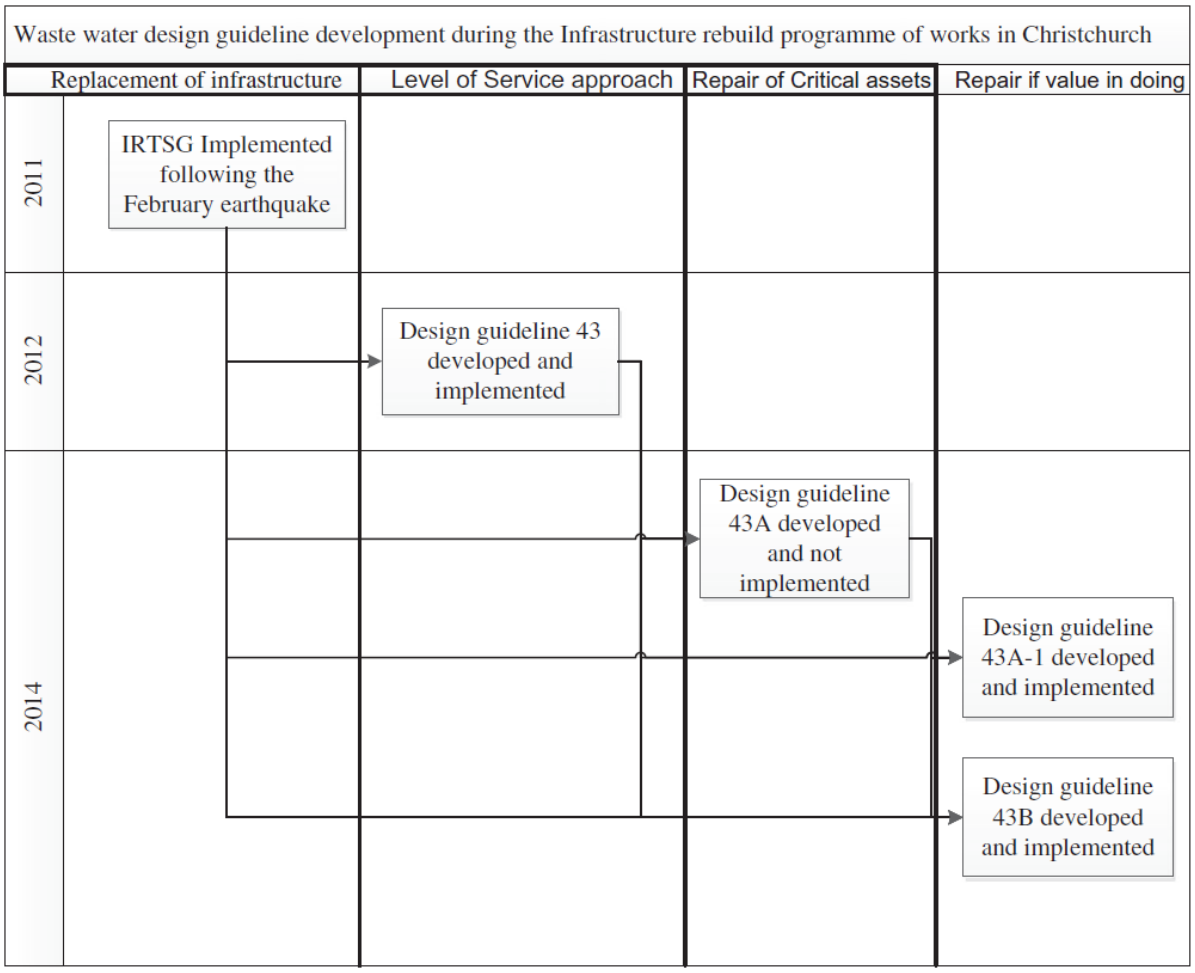

Figure 2: Development of design guidelines used during the Christchurch rebuild (Botha & Scheepbouwer, 2016)

2.7. Literature Review Summary

This literature review identified gaps in understanding of the motivations surrounding subcontractor engagement by principal contractors in heavy civil construction. The review shows

that while the theoretical benefits of engaging subcontractors in general construction is well documented, the actual experience and used of subcontractor in the civil construction industry is largely undocumented.

Three key reasons for the use of subcontractors have been identified as:

1. The lack of skill/inability of a principal to self-perform the works.
2. Flexibility of a subcontractor to meet rapidly changing labour demands.
3. A subcontractor's ability to deliver the works for a lesser cost than the principal is able to self-perform.

A review of the SCIRT Alliance contract identifies that it presents a unique environment in which to observe the subcontracting strategies of multiple principal contractors simultaneously. Although, there are constraints which may distort observations and limit the application of any findings outside of the Alliance contract environment. These observations may provide a better understanding of how to optimise sub-contracting in civil construction.

3. METHODOLOGY

This section provides an overview of the methodology adopted for this research. Discussions centre on the method and the strategy used in data acquisition. This chapter also discusses the commercial sensitivity of the research and the necessary agreements entered into to afford access to data.

3.1. Research method

A two-stage quantitative and qualitative approach to this research was adopted:

- Statistical analysis of financial and productivity data sourced from the SCIRT alliance records was used to investigate potential correlations between the proportions and type of work subcontracted with financial performance against TOC.
- Following this data analysis, a series of qualitative questionnaires/interviews was conducted with principal Alliance delivery team leaders to investigate potential explanations for the observed trends and subcontract strategies.

3.2. Research Strategy

Figure 3 presents a flow chart of the research activities employed to achieve the research objectives. This includes a broad review of the literature, collection and analysis of data, and extraction of conclusions.

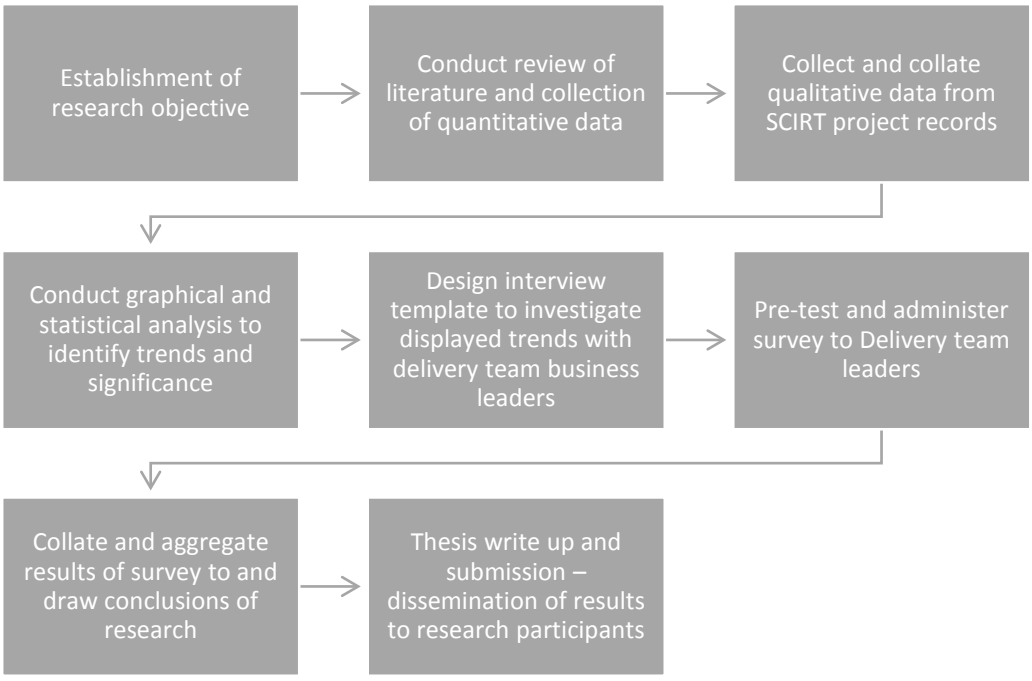

Figure 3: Flow chart of research activities.

3.3. Data collection methodology

Potential data sources for this research were identified by consultation and discussion with SCIRT staff and executive leaders. As a result, data was pursued from two distinct sources:

1. SCIRT Project records for productivity, financial and labour data.
2. The aggregated opinions and views of key decision makers amongst the delivery teams

The SCIRT project records and data procured for this research was not originally collected with the original intention of being part of this study. As such this data is categorised as being sourced from a secondary data source. The aggregated opinions were collected for the purposes of this study and as such are considered a primary source of qualitative data.

The collection mechanism, and survey design, required to gather the opinions and views of key decision makers amongst the delivery teams is dependent on the results and analysis of quantitative SCIRT project data. Therefore, it was decided to proceed with a sequential two stage process. Quantitative data collection was the first stage. The acquisition and analysis of project records sought to record observations and identify trends in subcontracting throughout the SCIRT programme. These observations were then able to be utilised to formulate an appropriate method with which to interrogate delivery team leaders and gather the necessary qualitative data.

3.3.1. Qualitative data collection

A questionnaire survey was designed to record responses from delivery team personnel who had influence over the management of, or decision to use (or not to use), subcontractors within SCIRT. The questionnaire was designed to measure latent variables that may provide meaning to the observations made in the analysis of the secondary data source.

The relevance and design of the interview questionnaire was tested via a pre-test interviews with two delivery team executives - these executives were chosen for their interest in the subject and willingness to assist in the research process. The feedback from these pre-tests confirmed the validity of the interview questionnaire and afforded some changes to be made to the final questionnaire.

Using a five-point Likert scale from 1 to 5, where 1 symbolizes ‘strongly agree’ and 5 represents ‘strongly disagree’ respondents were asked to rank statements made on: motivating factors in deciding to utilise subcontractors; the effects of using subcontractors; and the importance of other factors on project performance measures (Appendix 3). This approach to scaling responses in the questionnaire was adopted for two primary reasons;

1) Suitability of Likert-type scales to the measurement of latent variables, and ease of data analysis.
2) The ongoing use of Likert scales in prior studies of engineering management (Chang-Richards, Wilkinson, Seville, & Potangaroa, 2011). The questionnaire also requested for respondents to comment on any other potential factors and rate them accordingly.

3.3.2. Quantitative data sources

Project data was procured though the internal SCIRT data archives. A large portion of the data was stored in bespoke cloud based data repository called 'HiVis'. This facility was created for SCIRT staff, delivery team managers, and project managers to gain an overview of how teams and projects performed. Configured for each user, the system displays project dashboards and data in charts and tables. The system aggregates the data reported from numerous sources across the program, which are updated monthly. The databases behind this facility were extracted and used as the basis of the quantitative data source.

The data source utilised was split into two levels of detail: project data, and monthly data. Project level data was available for records of financial performance and subcontractor engagement. However, non-cost performance measures were not recorded at the project level, and were only available as monthly aggregations for each delivery team. This difference will necessarily effect the analysis technique in interrogating each level of data.

3.4. Commercial Sensitivity

In order to afford industry backing, this research has been carried out in complete commercial sensitivity and anonymity. Data for this analysis was made available by the SCIRT Integrated Services Team (IST) with the approval of all the delivery team leads within SCIRT. A joint non-disclosure agreement was entered into to protect any commercially sensitive information from being disseminated without the due consultation (Appendix 2).

4. QUANTITATIVE DATA DESCRIPTION

The details of 731 individual projects were made available for the study in May 2016. Of the initial 731 projects, 457 (63%) had TOC and subcontract usage data available (Table 5). The balance of projects, without required data, fall into one of the following three categories (R. Wesley, personal communication, May 23, 2016):

Table 5: The number of SCIRT projects by Project status at May 2016

Project Status	Number of Projects	Projects with required data
Concept Design	2	0
Detailed Design	8	0
TOC	9	0
Construction Allocation	2	0
Construction	130	123
Handover	33	31
Practical Completion	210	207
Project Completion	337	96
Total	**731**	**457**

- The TOC value had not yet been completed, i.e. the project has not passed through the TOC phase
- A project had negligible construction costs – few or no physical works
- A project originated in the IRMO prior to the establishment of SCIRT - these projects did not have TOC values estimated.

334 of the projects with available data are deemed by the IST to have either Handover, Practical Completion or Project Completion status (Table 5, Description of project status see 2.6.3- Page 10). These 334 projects are the sample of data used in this analysis, referred to as the 'sample projects'.

4.1. Introduction of observed continuous variables

In this section, the three key scale variables that were analysed are defined and discussed.

4.1.1. TOC Performance

As discussed (section 2.6.3, page 10) TOC (Target Outturn Cost) is the estimated total expenditure required to deliver the project. Internal SCIRT Estimators who act independently of the non-owner Alliance participants use a master pricing schedule and productivity schedule to build the target cost of a project. The total actual costs (TAC) are the costs incurred by the delivery team TOC

performance is the projects TAC as a proportion of its TOC value. Descriptive statistics for TOC performance data are available in Table 6 (page 23), a frequency distribution shows the data displays symmetric central tendency that supports an assumption of normality (Figure 4).

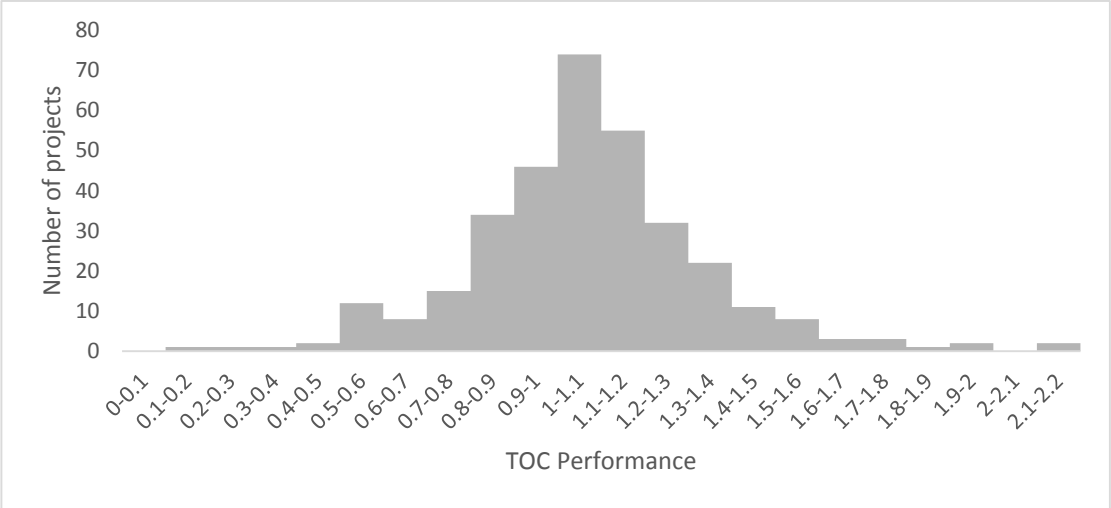

Figure 4: Frequency Distribution of sample projects TOC Performance

4.1.2. Subcontracted Proportion

The proportion of work subcontracted in a project is measured in two distinct ways.

1. At a project level, comparing the total expenditure on subcontractors with project Total Actual Costs.
2. At a month level by comparing the total subcontracted man hours with the total actual man-hours.

Subcontracted proportion data displays non-normal characteristics when observed as a frequency distribution (Figure 5). As described in section 2.6.6 (page 14) subcontracted performance is bound between a fixed upper where 100% of the project was performed by subcontractors, and a lower constraint that a minimum of 40% of total expenditure must be completed through subcontracts. With these constrains in mind, the observed skewedness of the data is expected. Descriptive statistics for subcontracted proportion data are available in Table 6.

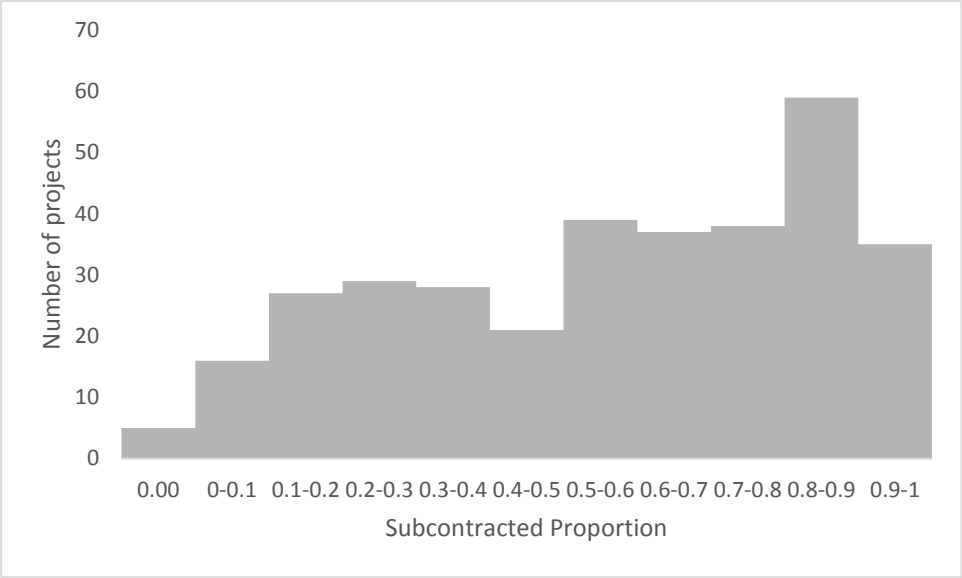

Figure 5: Frequency Distribution of sample projects subcontracted proportion

4.1.3. Non-Cost performance

As previously discussed in (section 2.6.5, Page 13) changes were made to the KRA framework during the SCIRT programme, both in how KPI were recorded and scaled to maintain a consistent focus on continuous improvements in non-cost performance areas (Gibb & Cameron, 2014). These changes make drawing comparisons between delivery team's performances on individual KRA's more complicated. As the DPS is inconsistent between months, the development of a consistent measure of non-cost performance is necessary to facilitate analysis over time.

The relative Non-Cost Performance Index (RNCPI) is a measure of non-cost performance relative to the monthly mean performance of all delivery teams. This index is calculated as the difference between the mean recorded monthly DPS of all delivery teams ($\bar{X}$) and a delivery team's recorded monthly DPS (X) (Equation 1).

Equation 1: Relative Non-Cost Performance Index

$$RNCPI = X - \bar{X}$$

Monthly records of DPS, total subcontracted man-hours, and total internal man-hours were made available for 34 consecutive months from July 2013 to April 2016 for this study.

The RNCPI frequency distribution shows the data displays a symmetric central tendency that supports an assumption of normality (Figure 6). Descriptive statistics for RNCPI data are available in Table 6.

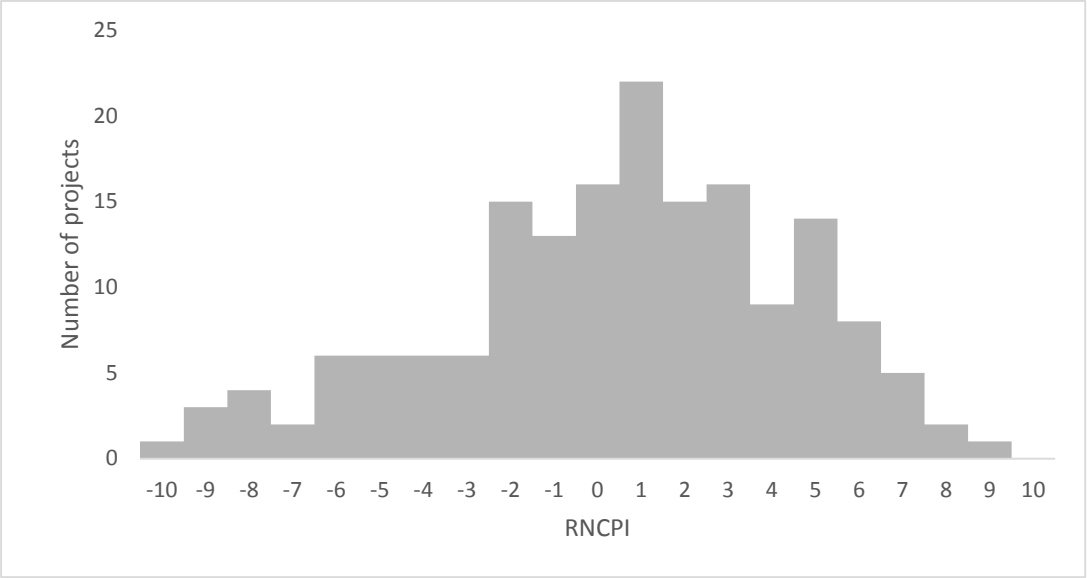

Figure 6: Frequency Distribution of sample projects Relative Non-Cost Performance Index (RNCPI)

4.1.4. Descriptive statistics and assumption of normality

The assumption of normality in the scale variable datasets is necessary for simple and efficient parametric data analysis. An assumption of normality allows a confidence interval based assessment of difference between categorical means.

The TOC performance and RNCPI data display consistency with the characteristics of the normal distribution. However, for the reasons discussed in 4.1.3 (page 22) subcontracted proportion does not display these same normal characteristics. For the purposes of this study, normality is assumed across all there scale variables and the potential effects of this considered negligible.

Table 6: Descriptive statistics of observed continuous variables

Statistic	***TOC Performance***	***Subcontracted Proportion***	***RNCPI***
Mean	0.97	0.56	0.00
Standard Error	0.02	0.02	0.31
Median	0.95	0.60	0.36
Standard Deviation	0.28	0.28	4.02
Sample Variance	0.08	0.08	16.17
Range	2.03	1.08	19.05
Minimum	0.08	0.00	-10.23
Maximum	2.11	1.08	8.82
Count	334	334	170
Confidence Level (95.0%)	0.03	0.03	0.61

4.2. Introduction and description of categorical interaction variables

The extent of the data available for the sample projects afford the ability to investigate the relationship between the proportion of work subcontracted with other project performance

measures – such as performance against TOC. However it also enables the ability to control these investigations for interactions with key categorical variables that may influence the result. Table 7 (Page 25) shows a summary of categorical variables which are investigated in the analysis.

Table 7: Categorical variable summary, description and levels.

Categorical Variable	Description	Levels
Delivery team	Denotes which of the five contractor alliance participants completed the delivery of the sample project	A
		B
		C
		D
		E
Value quartile	Denotes the project value quartile for each sample project	Q1
		Q2
		Q3
		Q4
Value Band	Project value category to achieve a\proportional category values	>12.5M
		>7.4M<12.5M
		>2.94<7.4M
		<2.94M
Project Scope categories	Individual project scope categorised by the nature of the construction work involved.	BR - Bridge
		MIX – Mixed type
		PS - Pump station
		RD – Road
		RW - Retaining Wall
		SW - Storm Water
		WS - Water Supply
		WW - Waste Water
Location	The location of individual sample projects within Christchurch. Based primarily on Christchurch City Council representative ward boundaries at the 2013 council elections, with the notable addition of a central city area.	Banks Peninsula
		Burwood-Pegasus
		Central City
		Fendalton-Waimairi
		Hagley-Ferrymead
		Riccarton-Wigram
		Shirley-Papanui
		Spreydon-Heathcote
Project start period	Individual project construction start month, grouped into thirds. Months 9-26 = T1, 26-43 = T2 and 43-59 = T3.	T1
		T2
		T3

5. QUANTITATIVE DATA ANALYSIS

In this section, analysis of the data procured from the SCIRT 'Hi-Viz' database (the secondary data source) is presented.

Firstly the relationship of subcontracted proportion, and TOC performance to the six categorical variables (as discussed in section 4.2, Page 23) is presented, concluding with the presentation of a regression model to predict TOC Performance. The categorical variable analysis is presented in the following order:

1. Delivery team
2. Value (Value Quartile and Value band)
3. Project Scope
4. Projects Location
5. Project Start Period

Secondly the relationship between monthly non-cost performance and the proportion of work subcontracted is examined and presented.

5.1. Delivery Team; Subcontracting and Performance against TOC

The delivery team category provides the ability to distinguish between each of the five delivery teams. The delivery teams have been assigned a random letter A-E to provide anonymity as per the Non-disclosure Agreement entered into to facilitate this study (Appendix 2). Delivery teams are resourced by the following five companies:

- City Care Ltd
- Downer New Zealand Limited
- Fletcher Construction Limited
- Fulton Hogan Limited
- McConnell Dowell Constructors

The sample projects are not evenly distributed between the delivery teams with the proportion delivered by an individual team ranging between 12-26% of the total sample value (Table 8).

Table 8: Delivery Team Categories, total value and number of projects

Delivery Team	Total Value of Projects	Number of Projects
A	$139,179,871.82	59
B	$211,598,709.95	87
C	$188,940,758.39	58
D	$184,154,863.33	78
E	$100,449,044.36	52
Total	**$824,323,247.85**	**334**

5.1.1. Difference in subcontracted proportion between delivery teams

The mean proportions of project value subcontracted by delivery teams varies by more than 40%. Contractor C exhibits the highest mean proportion of 75%, while contractor E the lowest at 35% (Table 9). This difference and others, are significant at a significance level of 0.05, as can be observed in Figure 7. Delivery teams B&D did not display a significant level of difference between subcontracted proportions at 0.05 significance level, and neither did delivery teams C&A. This shows there are three significantly different levels of subcontractor engagement observed between the five delivery teams.

Table 9: Estimated mean proportion of project value subcontracted by delivery team.

Delivery Team	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	.688	.032	.625	.752
B	.516	.027	.463	.569
C	.753	.033	.688	.817
D	.529	.028	.473	.584
E	.348	.035	.280	.416

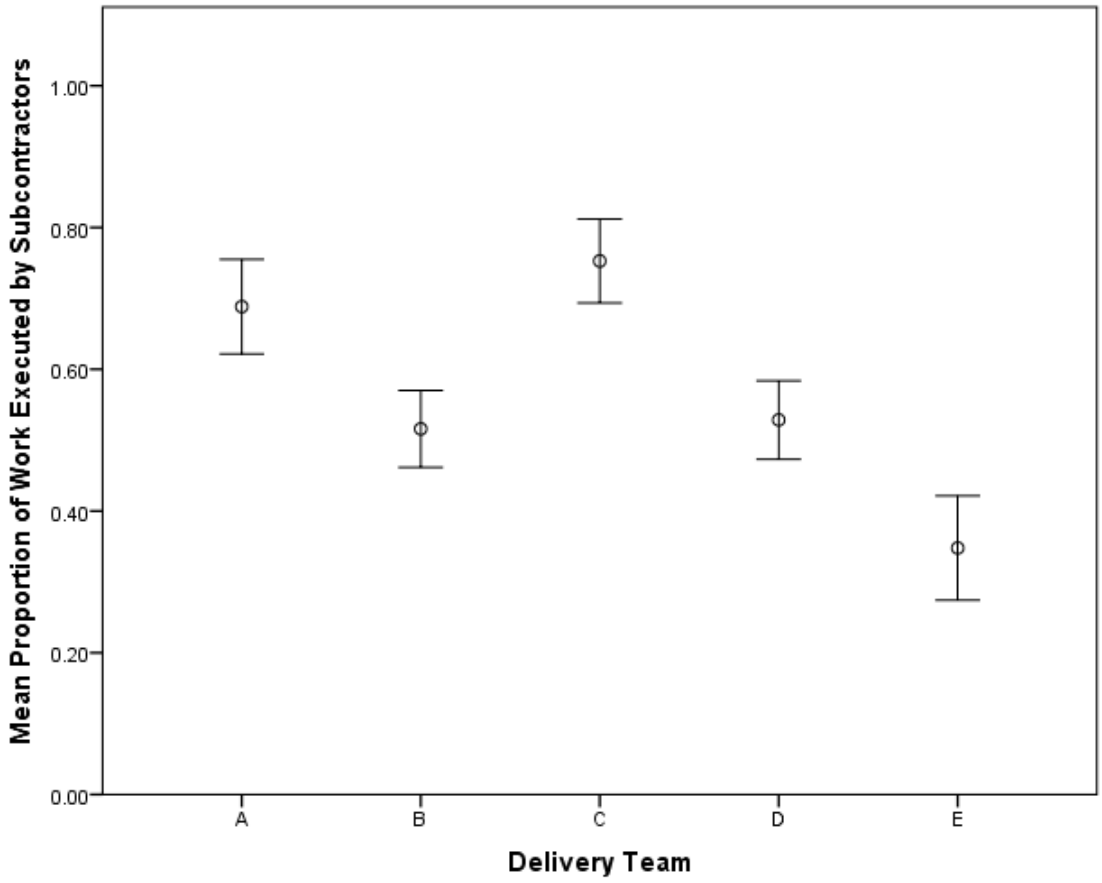

Figure 7: Mean proportion of project value subcontracted by delivery team with 95% confidence intervals

5.1.2. Difference in mean financial performance against TOC between delivery teams

The observed mean project expenditure of the five Delivery Teams ranges between 91% of TOC (delivery team B) and 108% of TOC (delivery team E). The difference between these two delivery teams (B&E) is significant at 0.05. However, this is the only significant (at α=0.05) difference in mean expenditure proportion between delivery teams observed.

Table 10: Mean project performance against TOC by delivery team.

Delivery Team	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	1.002	.036	.932	1.073
B	.917	.029	.859	.975
C	.954	.036	.883	1.025
D	.955	.031	.894	1.016
E	1.081	.038	1.006	1.156

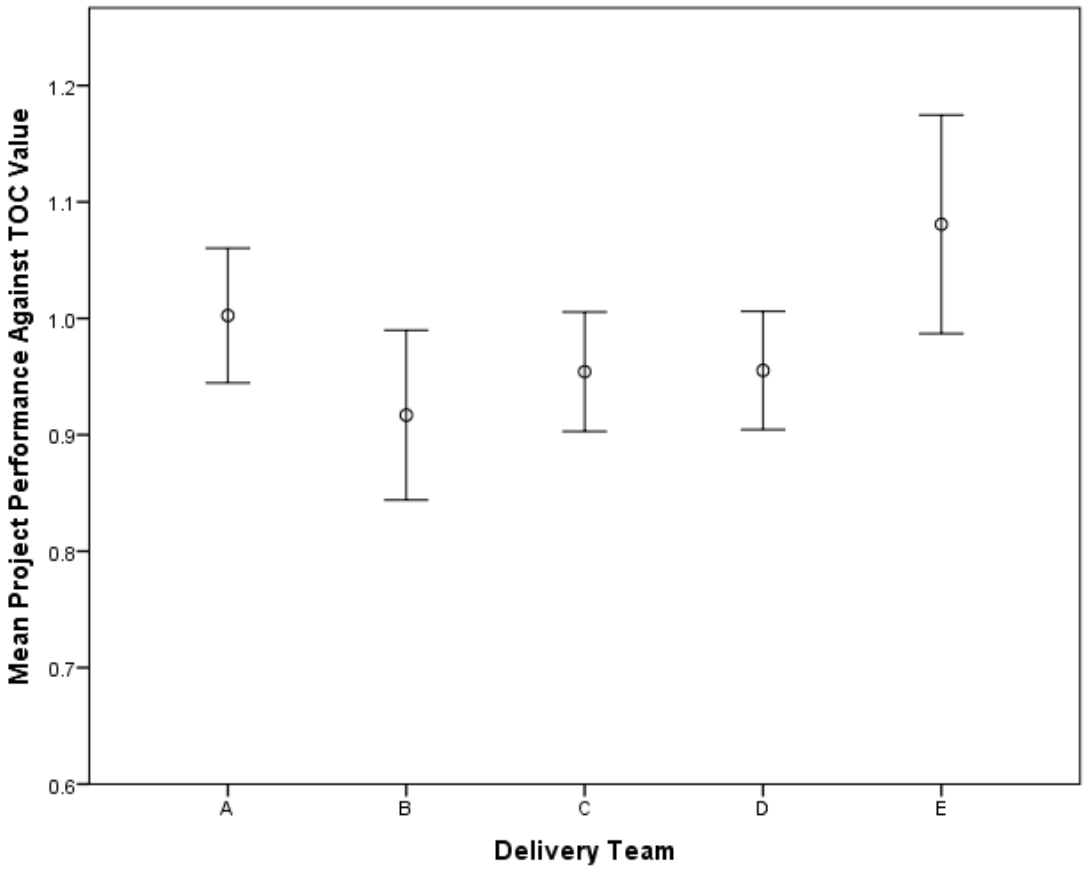

Figure 8: Mean project performance against TOC by delivery team, with 95% confidence intervals.

5.2. Project Value; Subcontracting and Performance against TOC.

The average value of a sample project is $2.46M, however this is heavily skewed with a median project value of $0.94M (Table 11).

Table 11: Descriptive statistics of sample project by total value

Mean	$2,468,033.68
Standard Error	$210,922.53
Standard Deviation	$3,854,749.83
Minimum	$1,084.89
Quartile 2	$231,219.85
Median	$936,469.54
Quartile 3	$2,751,784.57
Maximum	$21,923,191.43
Sum	$824,323,247.85
Count	334

The majority of the sample projects are of relatively small value. 51% of the sample comprises of projects with a value less than $1million, a further 17% has a value under 2 million. The frequency distribution of the sample projects is shown in Figure 9.

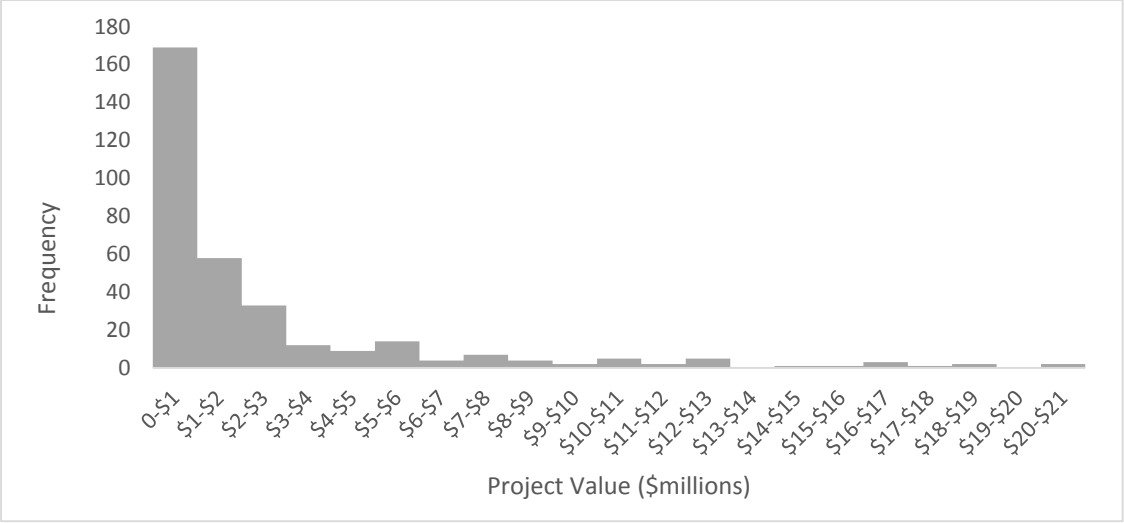

Figure 9: Frequency Distribution of sample projects by value

Table 12 shows the value distribution between quartiles of project data ranked by project value. Whilst the number of distinct projects in each quartile remains relatively constant, more than three quarters of the sample's total value is found in the fourth quartile alone. Conversely, the first quartile contains only 1% of the total sample value. To account for this a further

categorisation is developed to maintain a consistent category value. Four value bands each with a quarter of the total sample value. Combined, these categorisations permit the investigation of effects of project value on the dependant variables.

Table 12: Value distribution between quartiles and value bands of sample projects

	Category	Number of Projects	Combined Value	Proportion of total Value
Value Quartile	1	84	$9,633,804	1%
	2	83	$42,644,152	5%
	3	83	$134,576,556	16%
	4	84	$637,468,735	77%
Value Band	>12.5M	12	$203,732,248	25%
	>7.4M<12.5M	22	$211,646,544	26%
	>2.94<7.4M	46	$210,735,925	26%
	<2.94M	254	$198,208,531	24%

5.2.1. Project value effects on subcontracted proportion

There is a significant difference between the estimated mean proportion of project value subcontracted between the first and fourth project value quartiles. The first quartile has a mean proportion of 49%, this increases to a mean value of 64% in the fourth quartile (Table 12). There is no significant difference between any other quartiles. This is depicted graphically in Figure 10, which shows the differences between project value quartiles with error bars displayed at 95% confidence intervals

Table 13: Estimated mean proportion of project value subcontracted by value quartile and Value band.

	Category	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Value Quartile	Q1	.499	.030	.439	.558
	Q2	.543	.030	.483	.602
	Q3	.574	.030	.514	.633
	Q4	.642	.030	.583	.702
Value Band	<2.94M	0.53	0.037	0.457	0.603
	>2.94M<7.4M	0.659	0.112	0.438	0.881
	>7.4M<12.5M	0.701	0.12	0.464	0.938
	>12.5M	0.683	0.132	0.424	0.943

.

The mean proportion of project work subcontracted between the four value bands ranges between 53% and 70% (Table 13). There is no evidence to suggest a significant difference between the means (Figure 11). Though there is a marginal increase of 15.3% in the mean rate between the lowest value band and highest- the standard error of the means is such that this difference in not significant at 0.05.

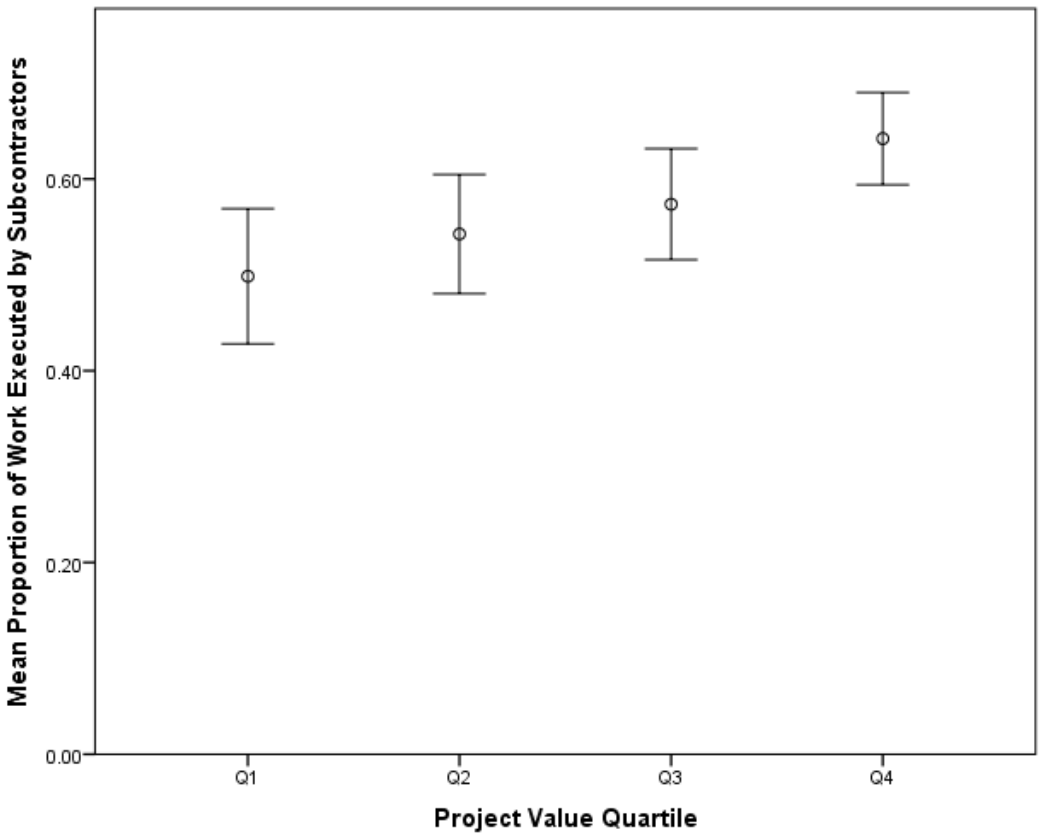

Figure 10: Estimated mean proportion of project value subcontracted by value quartile, with 95% confidence intervals.

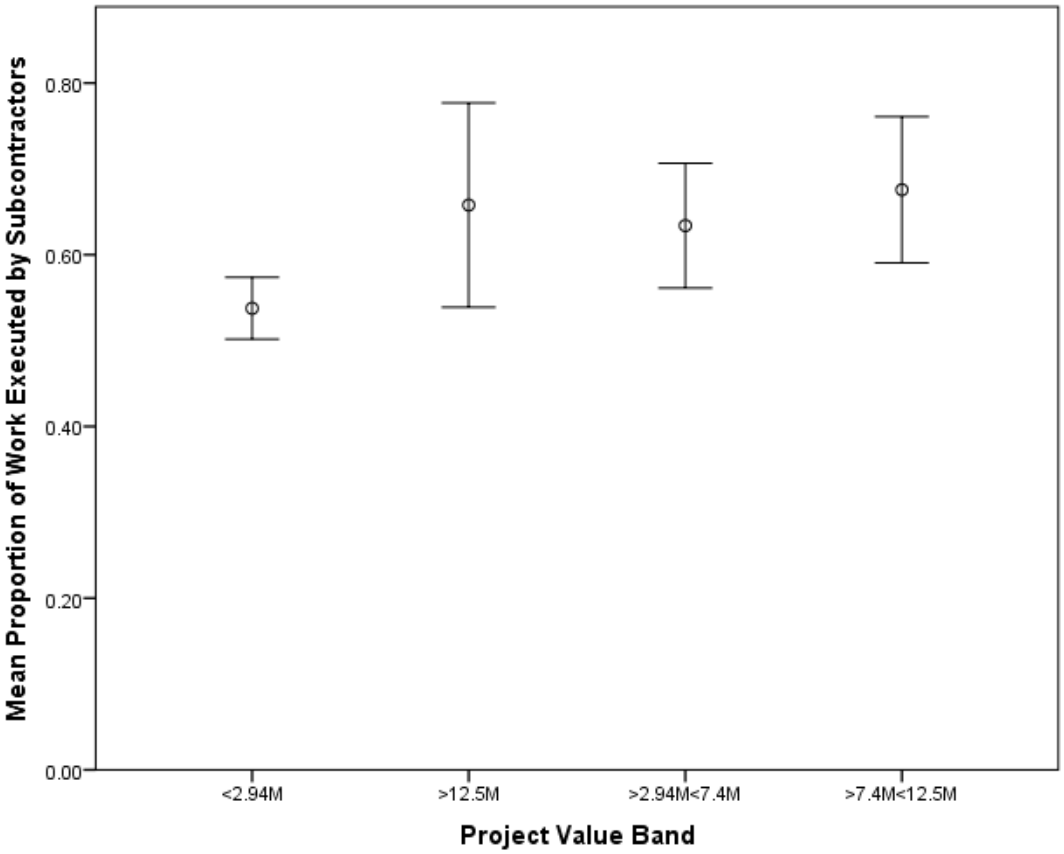

Figure 11: Estimated mean proportion of project value subcontracted by value band, with 95% confidence intervals.

5.2.2. Project value effects on mean project TOC performance

Table 14: Estimated mean proportion of project performance against TOC by value quartile and Value band.

	Category	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Value Quartile	Q1	.823	.029	.766	.880
	Q2	1.011	.029	.954	1.068
	Q3	1.031	.029	.974	1.088
	Q4	1.028	.029	.971	1.085
Value Band	<2.94M	.957	.017	.923	.992
	>2.94M<7.4M	1.015	.041	.934	1.095
	>7.4M<12.5M	1.012	.059	.896	1.129
	>12.5M	1.073	.080	.915	1.231

The mean project performance against TOC is significantly better in the first quartile than the second, Third and Fourth quartiles (Table 14). This trend continues when using the value band categorisation, with projects under 2.94M showing a significantly better performance compared

to the top Value band (Over 12.5M), however there is no significant difference with the two intermediate bands (Table 14).

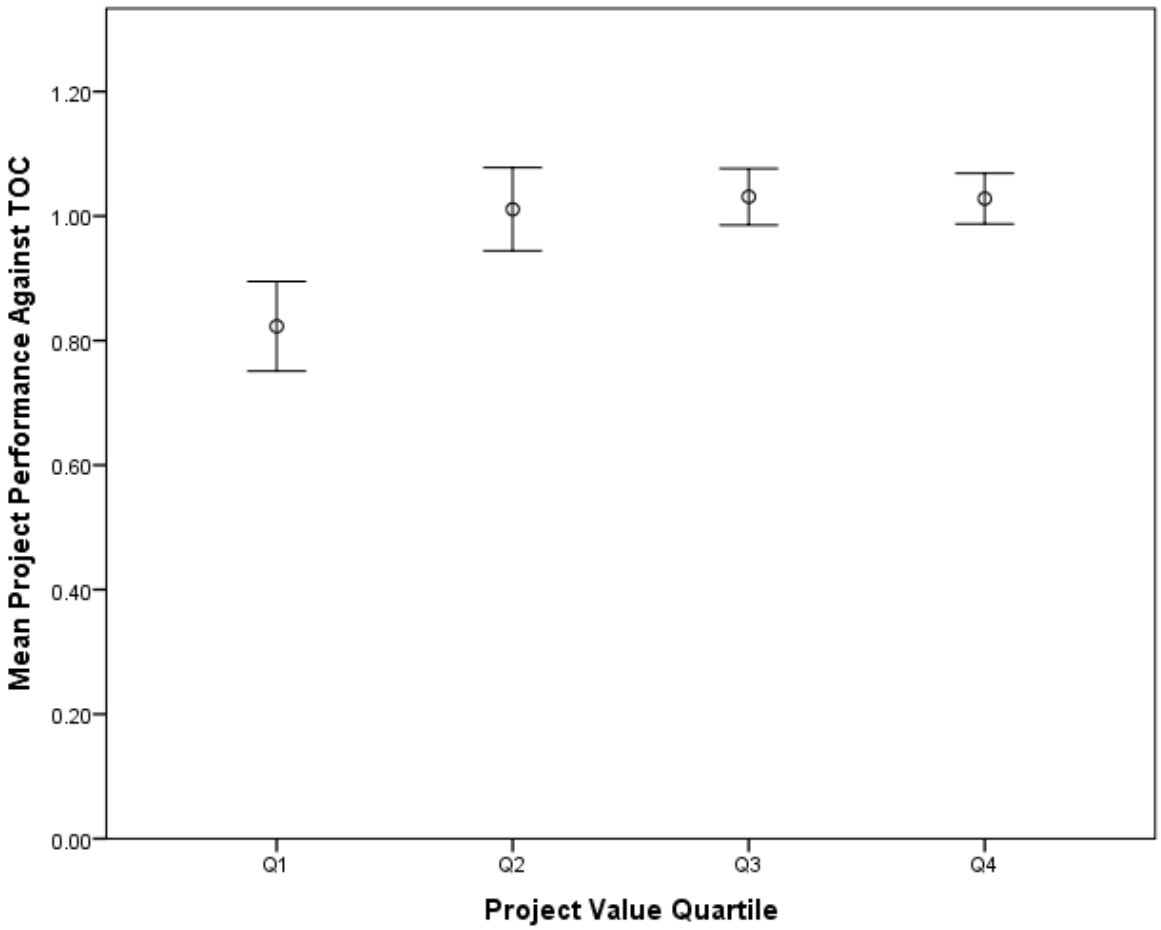

Figure 12: Estimated mean project performance against TOC by value quartile, with 95% confidence intervals.

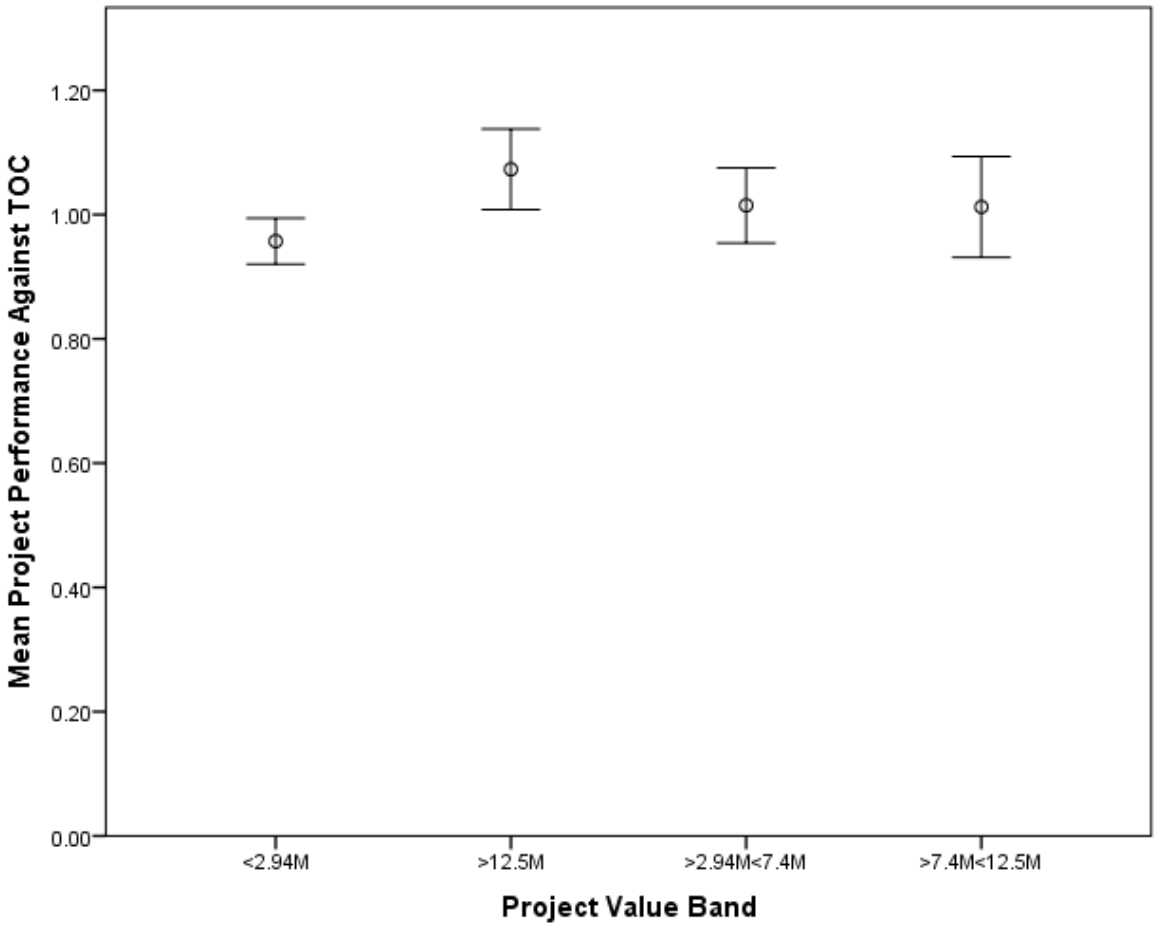

Figure 13: Estimated mean project performance against TOC by value band, with 95% confidence intervals.

5.3. Project scope; Subcontracting and Performance against TOC

The scope of work SCIRT was tasked with completing can be broadly categorised as repairs to horizontal infrastructure. However, individual project scope can be categorised in more detail by the type of work involved. The sample project set is categorised into eight different definitions depending on the nature of work involved (Table 15). 21% of the sample projects are categorised as 'mixed type', these are projects that included many different categories of work. For example; a project may have included road construction and waste water repairs. With 26% of the sample, the most common project type was waste water projects.

Table 15: Number of projects by scope category in sample

Project Scope category	Delivery Team					Overall	
	A	B	C	D	E	Total	Proportion
BR - Bridge	5	1	5	13	1	25	7%
MIX – Mixed type	17	17	11	15	11	71	21%
PS - Pump station	3	3	3	3	4	16	5%
RD – Road	4	11	3	13	9	40	12%
RW - Retaining Wall	7	11	8	10	6	42	13%
SW - Storm Water	2	2	1	-	2	7	2%
WS - Water Supply	5	26	4	4	6	45	13%
WW - Waste Water	16	16	23	20	13	88	26%
Total	**59**	**87**	**58**	**78**	**52**	**334**	**100%**

5.3.1. Project scope effects on subcontracted proportion

Table 16: Estimated mean proportion of project value subcontracted by project scope.

Type	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
BR	.560	.053	.455	.665
MIX	.608	.032	.545	.671
PS	.581	.067	.449	.712
RD	.381	.042	.299	.463
RW	.449	.041	.369	.529
SW	.590	.101	.391	.788
WS	.582	.040	.504	.661
WW	.659	.028	.603	.715

The mean proportion of project work subcontracted varied from 38% for roading projects, to 65% for waste water projects (Table 16). There were significant differences in the mean level of subcontracting between various groups (Figure 14). Roading projects displayed a significantly lower mean subcontracted proportion than wastewater and water supply projects.

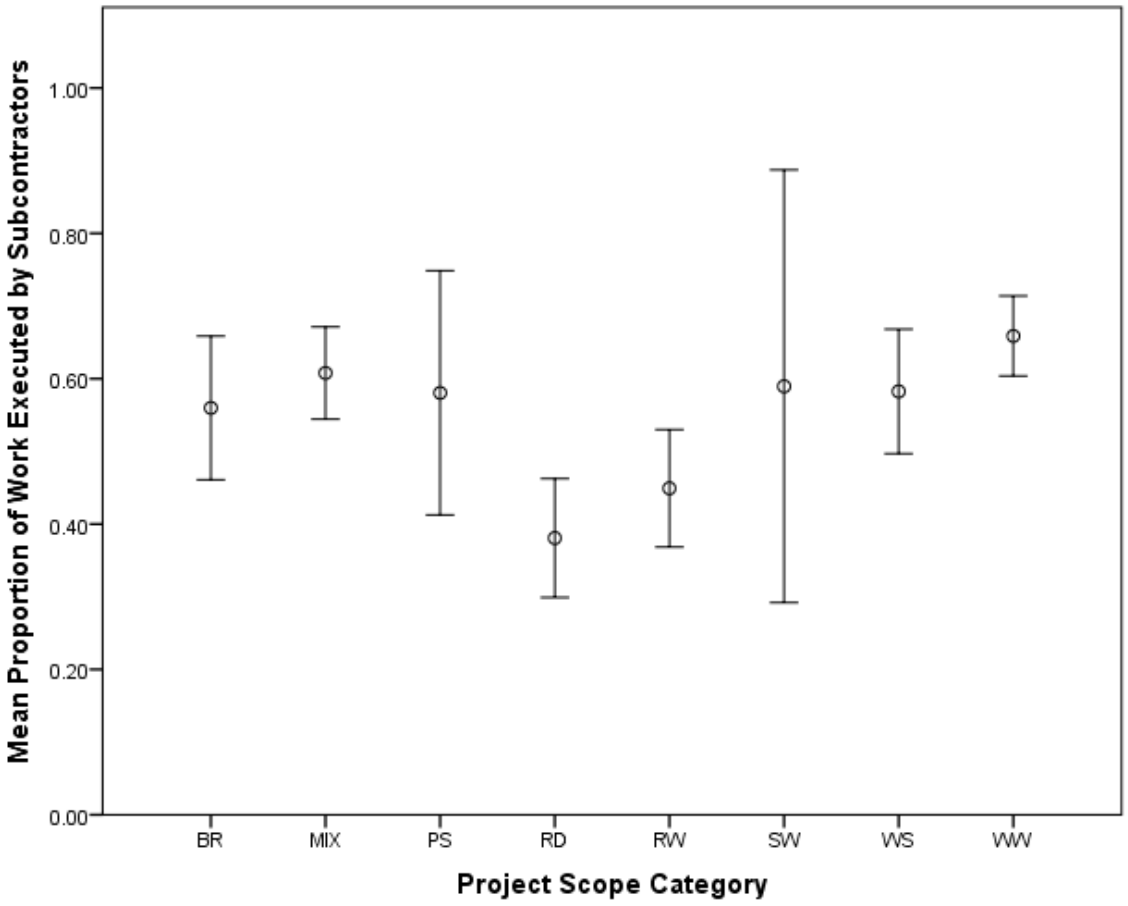

Figure 14: Estimated mean proportion of project value subcontracted by project scope category, with 95% confidence intervals.

5.3.2. Project Scope effects on mean project performance against TOC

Table 17: Estimated mean proportion of mean project performance against TOC by project scope.

Type	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
BR	.946	.054	.840	1.052
MIX	1.028	.032	.964	1.092
PS	1.133	.067	1.000	1.265
RD	.907	.042	.824	.990
RW	.885	.041	.804	.966
SW	1.144	.102	.944	1.344
WS	.862	.040	.783	.941
WW	1.025	.029	.969	1.082

The mean project performance against TOC varied from 114% for Storm Water projects, to 86% for water supply projects (Table 17). There were significant differences observed in the mean level of subcontracting between various groups (Figure 15)

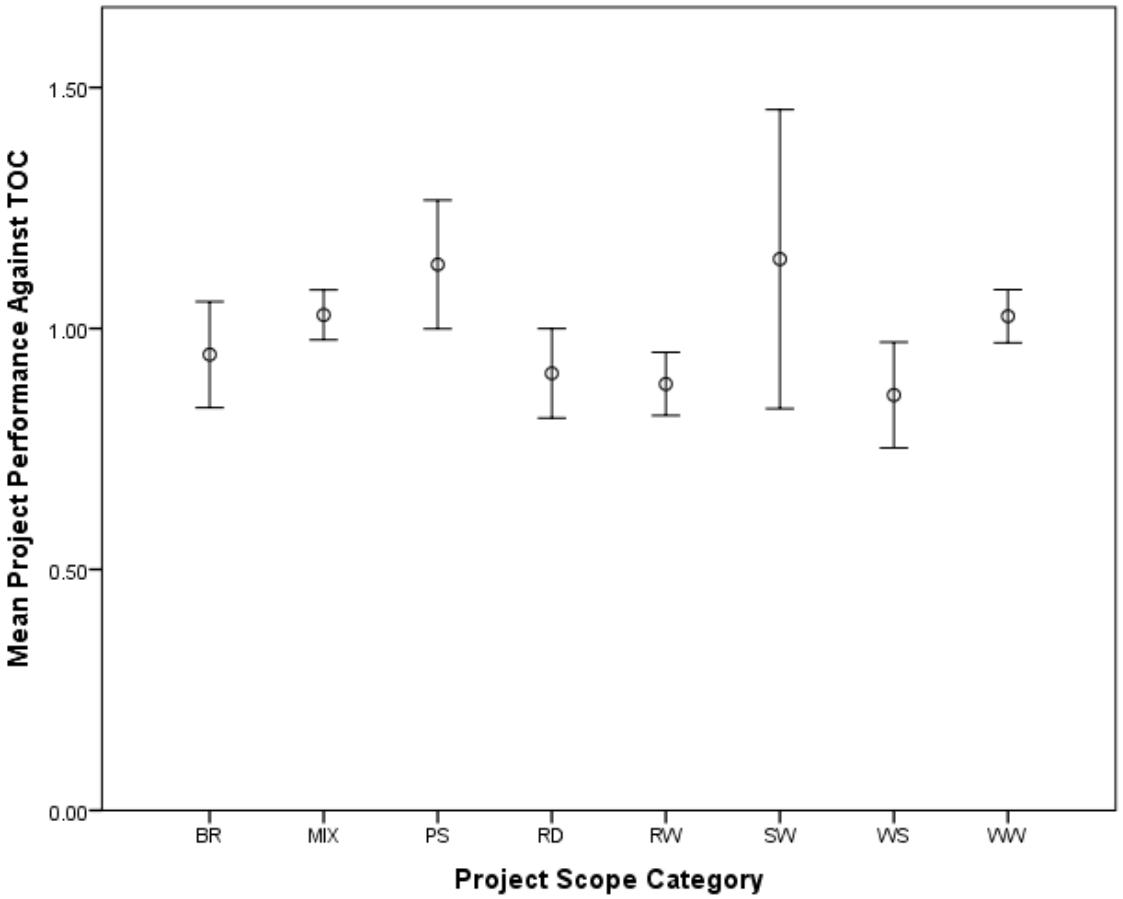

Figure 15: Estimated mean project performance against TOC by project scope, with 95% confidence intervals.

5.4. Location; Subcontracting and Performance against TOC

The entire SCIRT project is geographically confined to the city of Christchurch by the local government boundary. However, individual projects can be further categorised geographically by the representative council ward that they are within. Seven representative wards were initially put in place for the 2013 Christchurch City Council elections – and with the added distinction if a Central City ward these boundaries remained a useful way to categorise the projects within SCIRT (Table 18). These wards can be further broken down into drainage catchments, however for the purposes of this study the eight wards will suffice. The Central City ward is the rectangular area contained within 'The four Avenues' (Moorehouse Ave, Bealey Ave, Fitzgerald Ave, and Deans Ave). Detailed maps of the ward areas are included for reference in Appendix 4.

Table 18: Number and total value of project by council ward locations.

Ward	Total Value of Projects	Number of Projects
Banks Peninsula	$20,372,535.16	22
Burwood-Pegasus	$254,497,530.44	82
Central City	$96,684,458.75	32
Fendalton-Waimairi	$41,483,376.12	16
Hagley-Ferrymead	$224,929,900.96	109
Riccarton-Wigram	$16,882,342.87	11
Shirley-Papanui	$64,185,401.51	28
Spreydon-Heathcote	$105,287,702.04	34
Grand Total	**$824,323,247.85**	**334**

5.4.1. Project Location effects on subcontracted proportion

Table 19: Estimated mean proportion of project value subcontracted by project location.

Location	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Banks Peninsula	.305	.057	.192	.418
Burwood-Pegasus	.593	.030	.534	.651
Central City	.682	.048	.589	.775
Fendalton-Waimairi	.449	.067	.317	.581
Hagley-Ferrymead	.569	.026	.519	.620
Riccarton-Wigram	.431	.081	.272	.591
Shirley-Papanui	.653	.051	.553	.753
Spreydon-Heathcote	.561	.046	.470	.652

The mean project proportion subcontracted ranged from 30.5% in Banks Peninsular to 68% in the Central City (Table 19). The Banks Peninsular ward showed a significantly lower mean project proportion subcontracted than five of the other wards. The remaining wards displayed no significant difference in their respective means (Figure 16).

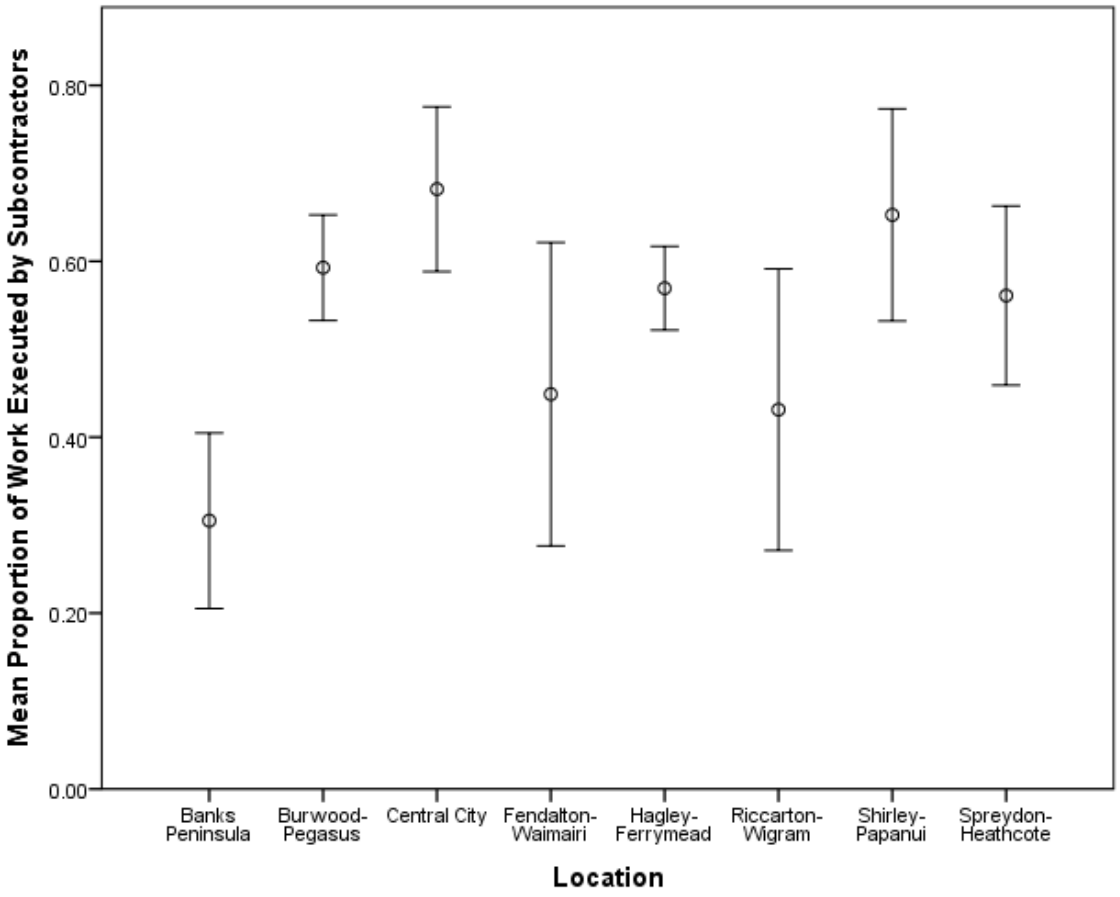

Figure 16: Estimated mean proportion of project value subcontracted by project location, with 95% confidence intervals.

5.4.2. Project Location effects on mean project performance against TOC

Table 20: Estimated mean project performance against TOC by project location.

Location	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Banks Peninsula	.863	.058	.748	.978
Burwood-Pegasus	.952	.030	.893	1.012
Central City	.967	.048	.872	1.062
Fendalton-Waimairi	1.036	.069	.901	1.171
Hagley-Ferrymead	.949	.026	.897	1.001
Riccarton-Wigram	1.187	.083	1.024	1.350
Shirley-Papanui	.981	.052	.879	1.083
Spreydon-Heathcote	1.072	.047	.979	1.164

There is no significant difference in the mean performance against TOC between project Locations.

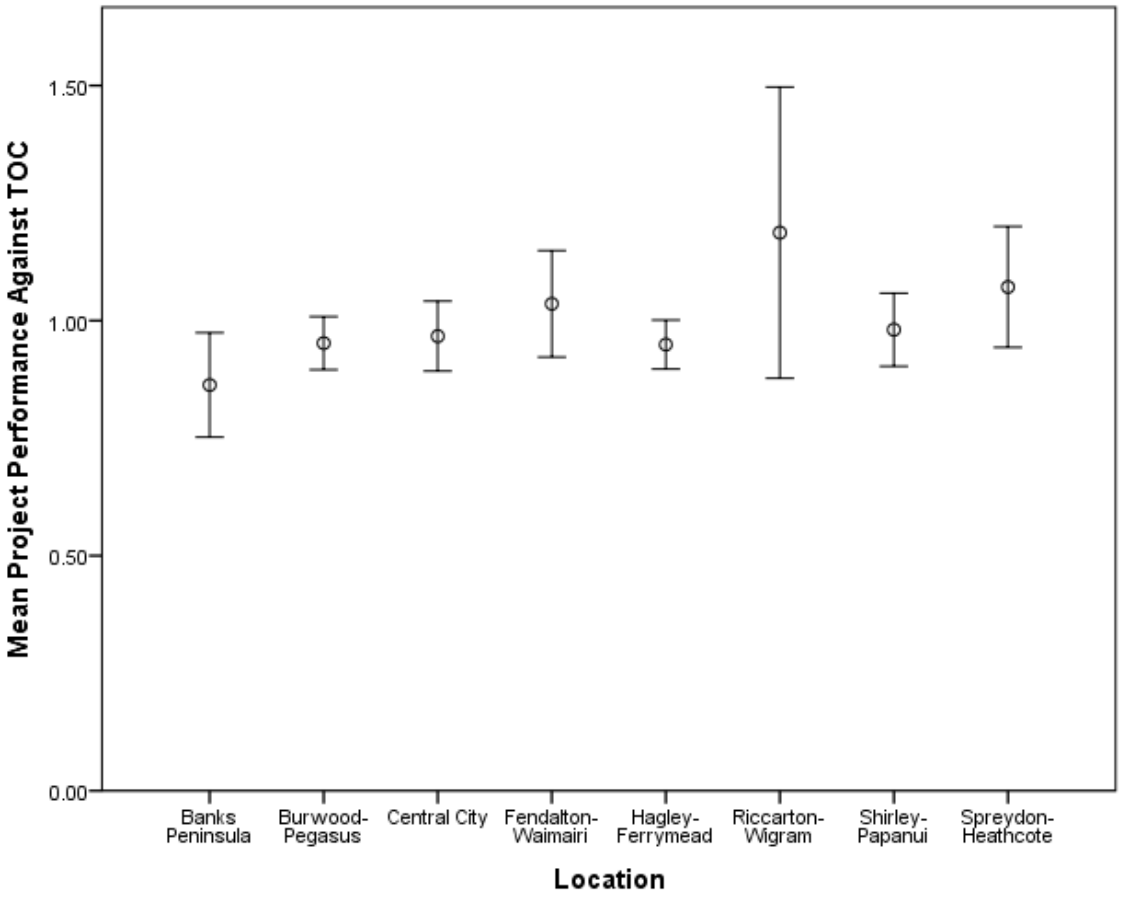

Figure 17: Estimated mean project performance against TOC by project location with 95% confidence intervals.

5.5. Project start Period; Subcontracting and performance against TOC

Due to the design of the SCIRT alliance agreement and financial incentivisation of collaboration between non-owner participants as a result of limb 3 payment provisions, it is expected that measures of delivery performance should increase over the course of the contract lifetime (Christchurch Infrastructure Alliance , 2011) (Provost, 2013).

This expectation is observed in the sample data. Over the course of the SCIRT programme the average sample project financial performance improved (Figure 18). At the beginning of the SCIRT programme average final costs were in excess of 110% of the total TOC allowance, this overrun is seen to drop away overtime, in the 59th month of the programme the average project spend was around 80%.

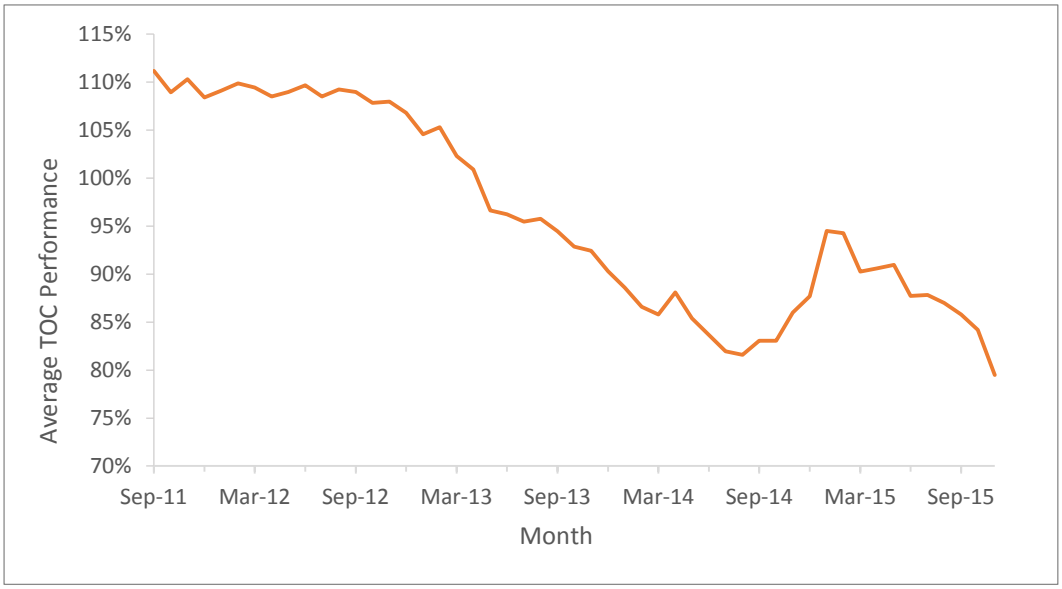

Figure 18: Project performance over time, as a rolling 12 Month average of project TOC performances.

To isolate this potential effect for analysis, the projects have been categorised in thirds by their start date (Table 21). This categorisation finds that the combined value of the projects within each programme period is not equal, the value and number of projects increased as the programme progressed.

Table 21: Project start date categories

Project Start Date	Number of Projects	Combined Value	Proportion of total Value
Sep11 – Feb13	83	$36,212,106.47	4%
Feb13 - Jul14	96	$275,120,339.65	33%
Jul14 - Nov15	155	$512,990,801.73	62%

Splitting the SCIRT programme into periods allows a comparison of the means for each programme third and significance testing of the data (Figure 19). The first third of the programme saw significantly lower performance against TOC than the final two thirds.

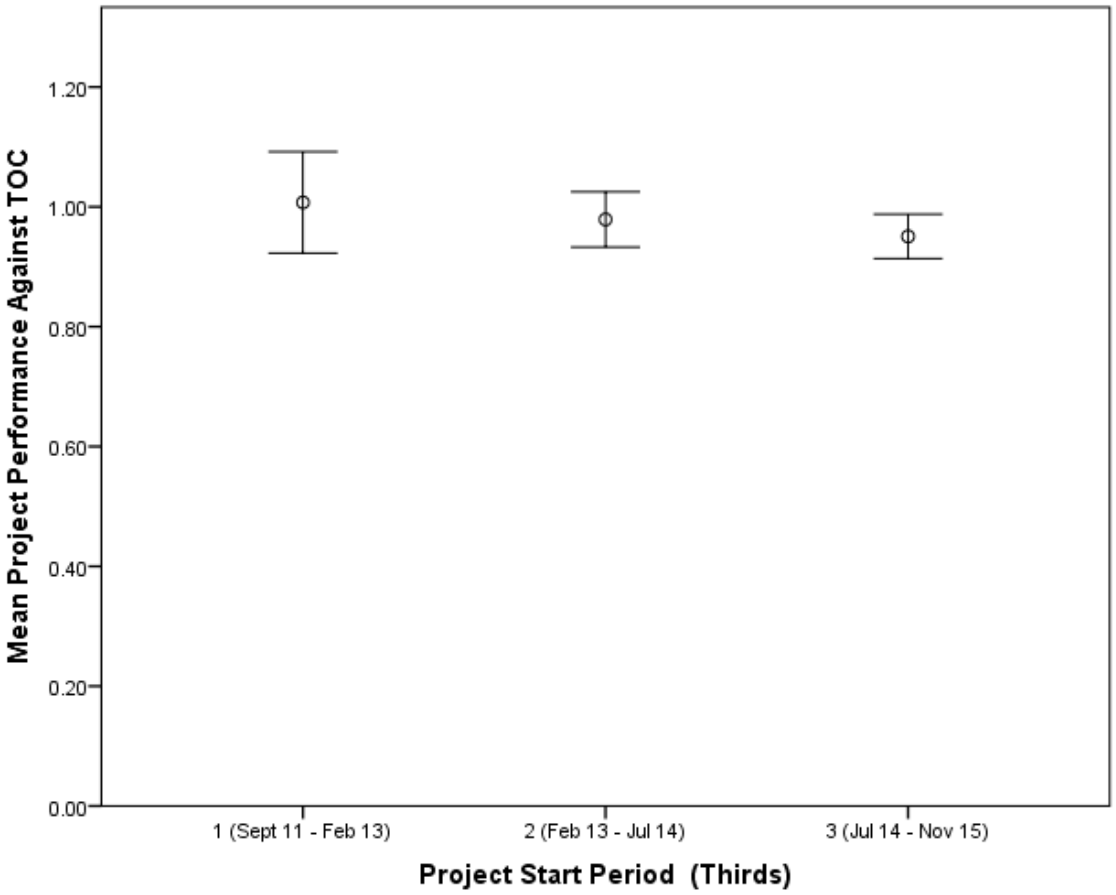

Figure 19: Average SCIRT project performance against TOC by Programme segment thirds, with 95% Confidence Intervals

Across these same thirds the average subcontracting rate remained steady, with no significant changes in the average rate between the thirds. Between 55 and 60% of the total spend was on subcontract firms (Figure 20).

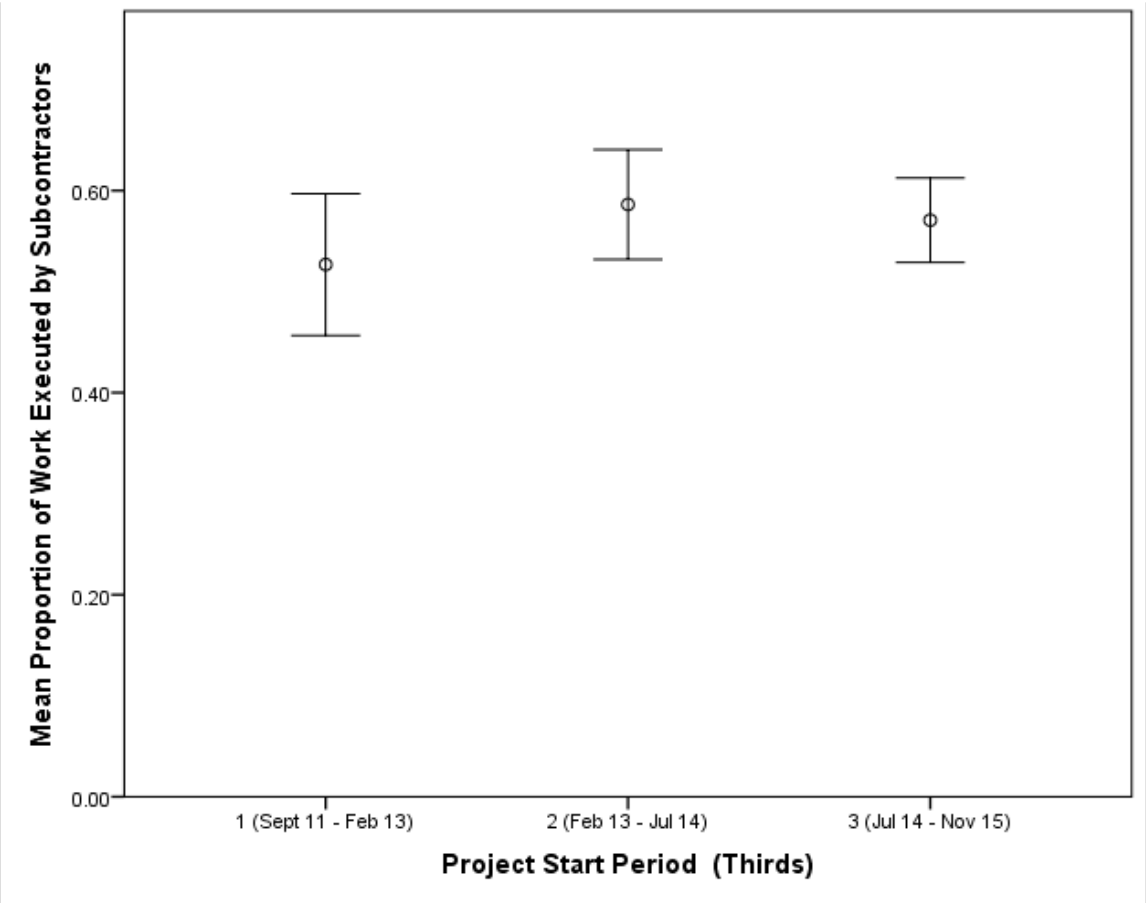

Figure 20: Mean proportion of project spend on subcontractors for all delivery teams by programme segment thirds, with 95% Confidence Interval.

However, the rate of subcontracting was found to be significantly different between delivery teams. Initially, there was a large difference in the amount of work subcontracted between delivery teams, in the early months on SCIRT this difference is particularly obvious - with one delivery team subcontracting more than 90% of the work and another letting only 20% (Figure 21).

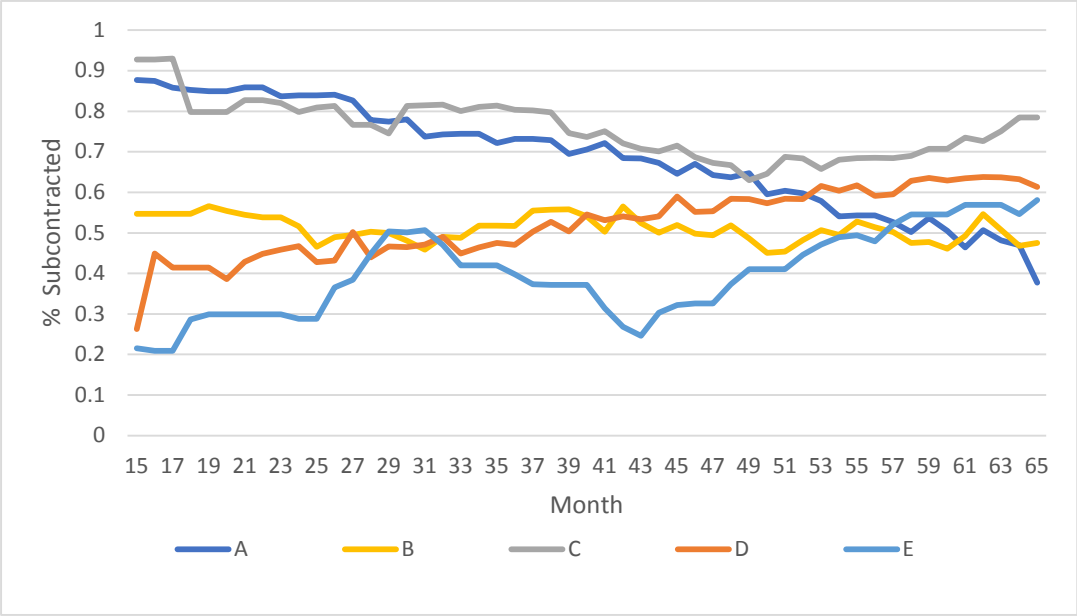

Figure 21: Rolling 12 month average of subcontracted proportion by DT

The significant differences between delivery teams becomes clear when viewed by programme segment with confidence intervals (Figure 22).

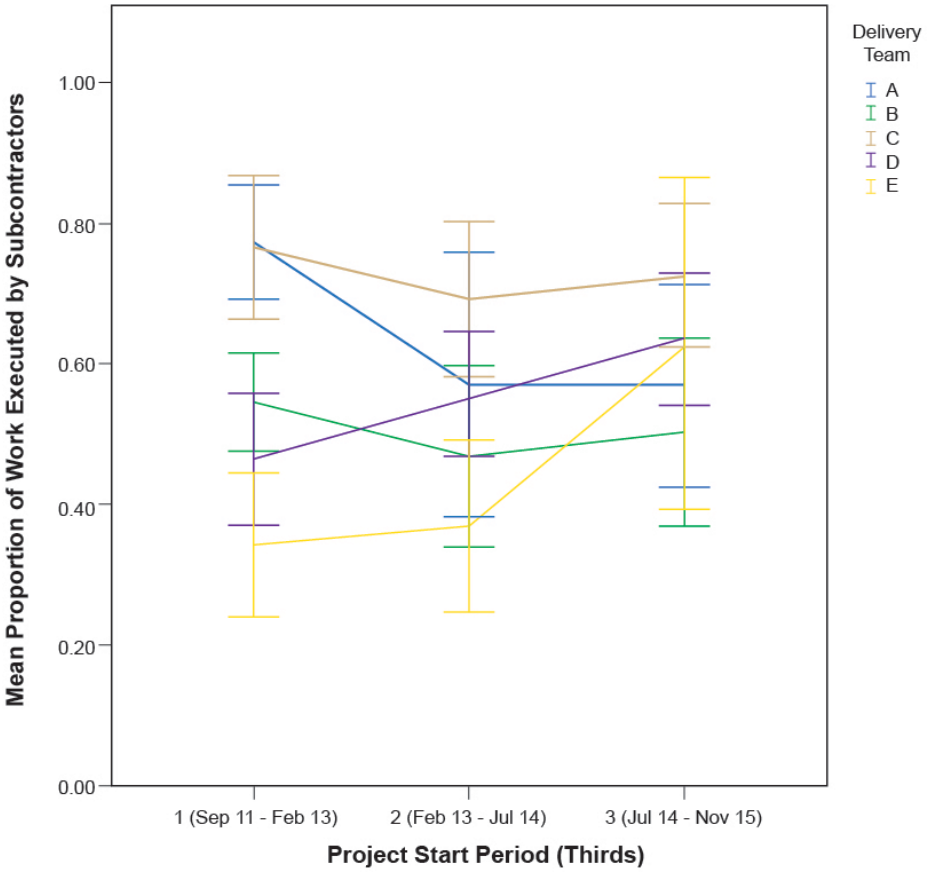

Figure 22: Mean proportion of project spend on subcontractors by Programme segment thirds with delivery team interaction and 95% Confidence Interval.

5.6. Subcontracting and Financial performance

The Sample data indicates that there are differences in financial performance of delivery teams, with the range of expenditure stretching 95% - 117% of the total allocated TOC allowance (Table 22).

Table 22: Delivery team financial performance and proportionate use of subcontractors.

Delivery team	Spend	Revised TOC	Subcontractor Spend	% of TOC Spent	% of Spend on Subcontractors
A	$139,074,231	$143,758,073	$100,289,348	97%	72%
B	$211,507,589	$210,973,975	$128,733,773	100%	61%
C	$188,940,758	$198,913,015	$148,964,011	95%	79%
D	$183,692,217	$187,846,365	$95,806,616	98%	52%
E	$100,371,970	$85,678,442	$46,699,625	117%	47%
Total	**$823,586,766**	**$827,169,871**	**$520,493,373**	**100%**	**63%**

Performance is correlated with the extent to which subcontractors are utilised by the Delivery Team. Figure 23 shows this correlation as the subcontracted portion of work decreases, proportion of TOC spend decreases. Contractors A&C perform the best, with the highest expenditure on subcontracts and contractor E has the worst financial performance and lowest expenditure on subcontracts. The exception to this trend are contractors D & B, where contractor B subcontracted 9% more work than contractor D, and performed 2% worse against TOC.

A linear regression using total expenditure on subcontractors to predict overall sample performance against TOC shows an R Square value of 0.545, the linear regression is statistically significant at a significance level of 0.155, or 84.5% (Appendix 1, Table 29).

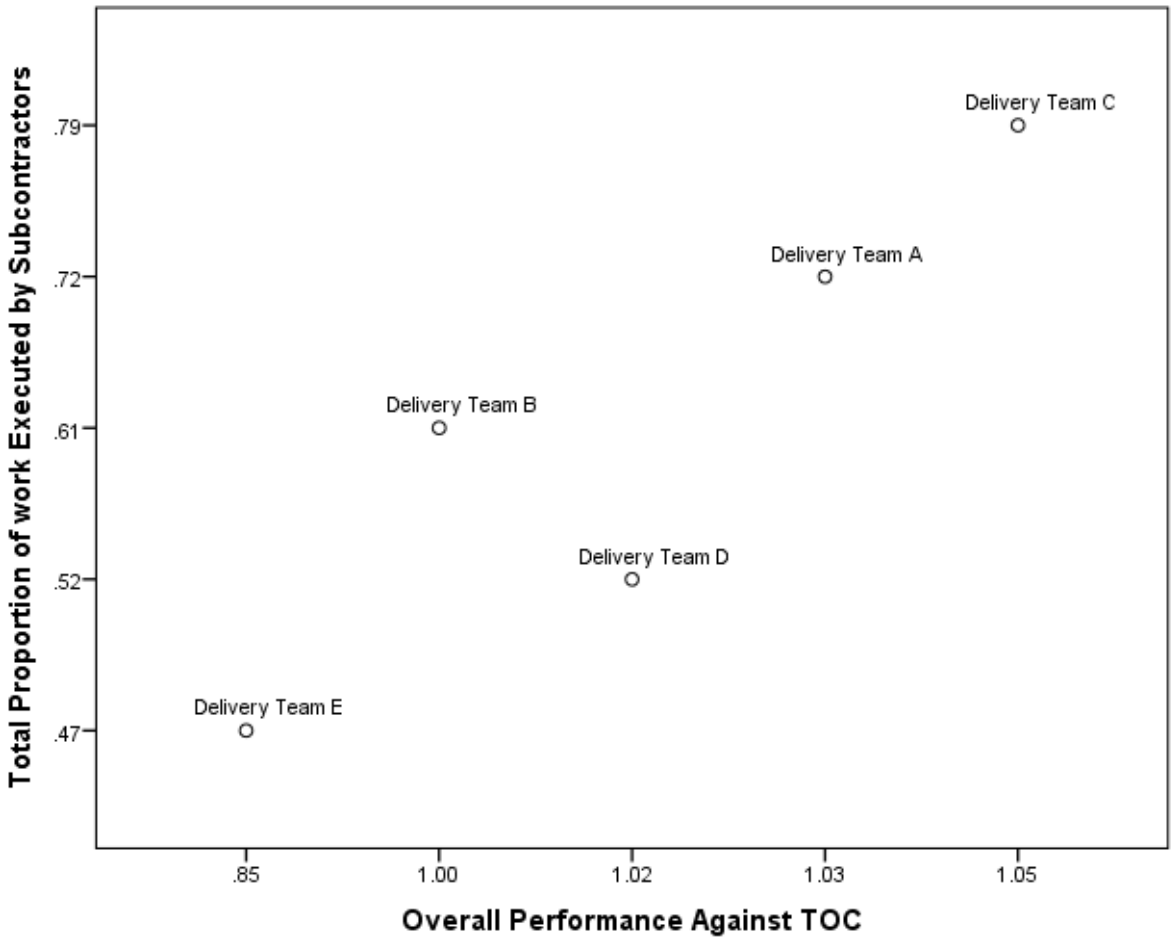

Figure 23 : Total proportion of delivery team expenditure on subcontracts vs the total expenditure proportion of TOC allowance.

5.7. Subcontracting and KRA performance

In this section non-cost performance is compared across delivery teams, and project start period. As discussed in section 3.3.2 (page 19) non cost performance data is limited to analysis of aggregated data reported monthly by delivery team. That is, summary data for all projects in the delivery phase for the reporting month. Project level non-cost performance data is not available for analysis.

5.7.1. A comparison of Non-cost performance between delivery teams

A comparison of mean RNCPI shows that there are significant differences in the relative non-cost performance between delivery teams (Figure 24). Delivery teams B&C performed significantly better than the other delivery teams.

Figure 24: Mean Relative Non-cost Performance Index between delivery teams for sample projects.

The average performance score for delivery teams B&C were respectively 3.6 and 2.5 percentage points higher than the average monthly mean non-cost delivery performance score for all teams (Table 23). The RCNPI for delivery team D was 0.4, while delivery teams A and E displayed the worst non-cost performance with a mean RNCPI of -2.4 and -2.3 respectively.

Table 23: Comparison of mean Relative Non-cost Performance Index between delivery teams for sample projects.

Delivery Team	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
A	-2.442	.515	-3.458	-1.425
B	3.620	.515	2.604	4.637
C	2.538	.515	1.521	3.554
D	-.399	.515	-1.416	.617
E	-3.317	.515	-4.333	-2.301

5.7.2. A comparison of Non-cost performance across programme period

A comparison of RNCPI across programme thirds shows that there were significant differences in non-cost performance of delivery teams as the SCIRT programme went on (Figure 25). For this analysis the sample data was spilt in to 11 month periods;

1) July 2013-May 2014,
2) June 2014- April 2015,
3) May 2015-April 2016.

Delivery team A showed consecutive significant improvements in relative non cost performance, while delivery teams D and E showed significant declines in RNCPI between periods 1-2 and 2-3 respectively. Delivery teams D&C did not show significant differences in Non-cost performance between programme periods.

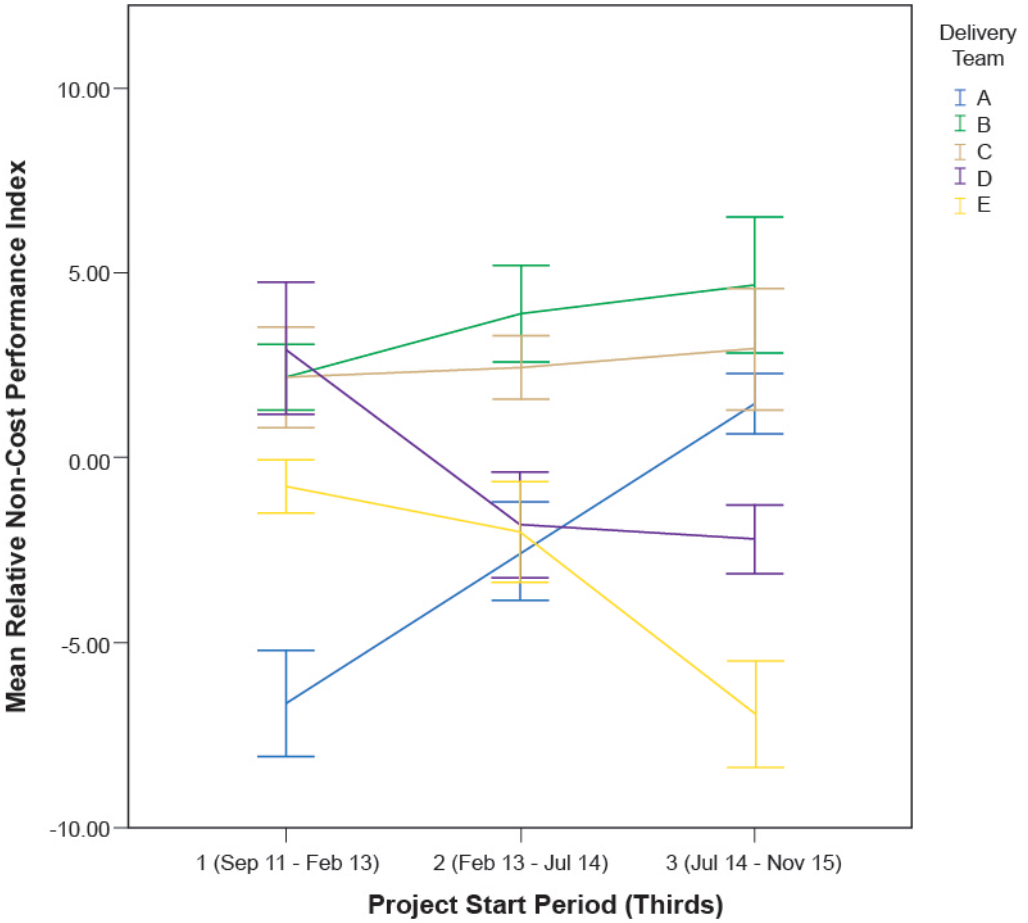

Figure 25: The mean Relative Non Cost Performance Index for each delivery team over programme period.

5.7.3. Non-cost performance and use of subcontractors

Differences in non-cost performance is also correlated with the extent to which subcontractors are utilised by a Delivery Team. As the proportion of total man-hours worked by subcontractors increased, relative non cost performance decreases.

A linear regression using the proportion of man-hours worked by subcontractors and delivery team to predict mean non cost performance (RNCPI) shows as the proportion of subcontracted hours worked increases, non-cost performance decreases. The regression has an R Square value of 0.600, a regression table is available in Appendix 1 as Table 29. Both the subcontracted proportion and the interaction between this proportion and individual delivery team have p-values of less than 0.05 and are therefore statistically significant at α=0.05. This suggests that non-cost performance decreases in as subcontractor use increases, by differing amounts depending on delivery team.

Linear regressions of the proportion of total man-hours worked by subcontractors on RNCPI for delivery teams A&C explain the most variation in the proportion of hours subcontracted, with R^2 values of 0.49 & 0.52 (Figure 26). While the same regression for Delivery teams B & C explained less than 5% of the variation in the data.

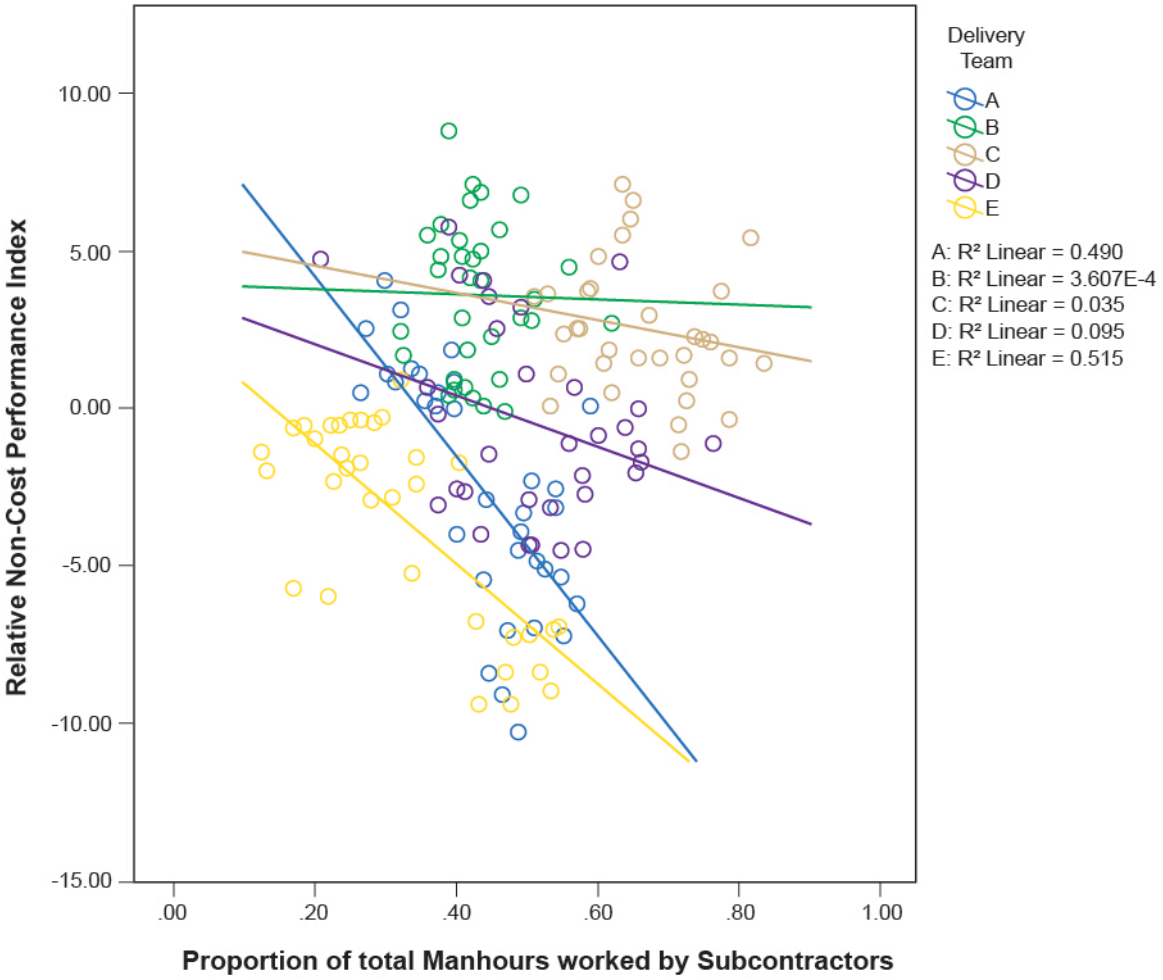

Figure 26: Monthly proportion of total man-hours worked by subcontractors' vs relative Non Cost Performance Index from July 2013 to April 2016.

6. QUALITATIVE DATA DESCRIPTION

A questionnaire was administered to 28 delivery team personnel who had influence over the management of, or decision to use (or not to use), subcontractors within SCIRT. Respondents from all delivery teams were sought to allow a full cross section of views from the delivery teams to be communicated (Table 24).

Table 24: Questionnaire respondents by delivery team.

Delivery team	Respondents	Percentage
A	5	18%
B	6	21%
C	6	21%
D	6	21%
E	5	18%
Total	28	

Respondents were sought from five organisational roles within the delivery teams (Table 25). The majority of respondents (57%) were in procurement management positions that had influence over the decision to engage (or not to engage) subcontractors, these being Senior Managers, Project Managers and Project Engineers. While the remaining 43%, were primarily involved in the practical management of subcontracted and internally delivered construction activities in the roles of Site Engineers and Superintendents.

Table 25: Questionnaire respondents by organisational role within delivery team.

Level of influence	Role	Respondents	Percentage
Procurement Management	Project Engineer	2	7%
	Project Manager	8	29%
	Senior Manager	6	21%
Construction Management	Site Engineer	10	36%
	Superintendent	2	7%
Total		**28**	**100%**

Respondents had worked within the SCIRT contract environment for between 1 and 5 years (Figure 27). The average tenure of respondents was just over 2 years, with the most common tenure being two years.

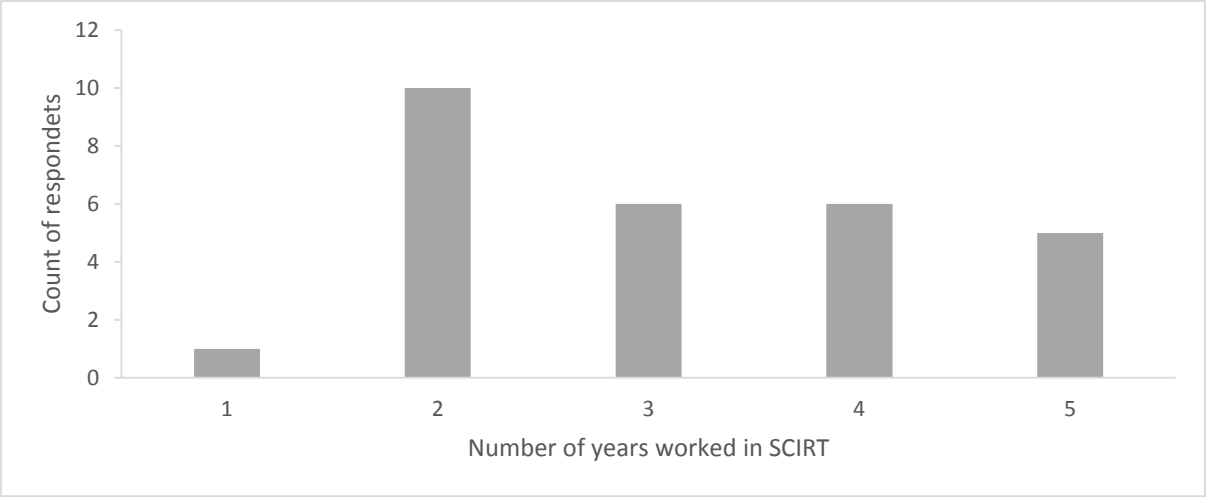

Figure 27: Number of years worked in the SCIRT contract by respondents to questionnaire.

7. QUALITATIVE DATA ANALYSIS

In this section, analysis of the data collected through interview questionnaires (the qualitative data source) is presented and analysed. The results and analysis in this section is organised into the following subsections:

1. The factors influencing the motivation to engage subcontractors on SCIRT projects
2. The perceived effects of utilising subcontractors on SCIRT projects.
3. Other general factors affecting the performance of a SCIRT project.

7.1. Motivation to use subcontractors

Subjects were asked to respond on a five point Likert scale to eleven Likert items, to assess their opinions on the motivating factors to engage a subcontractor over using internal resources. A summary of the results from this section of questions are presented in Table 26 (Page 56) and are represented visually in Figure 28 (Page 57).

Figure 28 displays the results items ranked by the proportion of total respondents who were in agreement with the statement posed. The highest ranked items consider the provision of required specialist resources, and the perceived ability to reduce financial risk to the principal contactor. For the most part, respondents did not consider that subcontractors rate of work, or management requirements, to be as important as resourcing considerations. 82% of respondents were either neutral or disagreed that internal delivery was more costly than subcontracting.

Respondents were also asked to supply general comments on the topic of motivations to engage subcontractors. One senior manager, echoing the results of the Likert scale, expressed their view that a key motivating factor was demand for specialist skills and plant; *"During the SCIRT project we were stretched for resources" "Subcontractors were used to meet the gaps in specialist skills and plant requirements in areas where the delivery teams did not keep a traditional large skill base."*

A project manager asserted that using subcontractors "gave us the flexibility to deliver large volumes of work, without large scale recruitment of skilled labour". This comment aligned with the third ranked Likert item which 82% of respondents agreed with; '(using subcontractors) provides flexibility to meet changing labour demands'.

7.2. Effects of using subcontractors

To assess the effects of engaging subcontractors over using internal resources subjects were asked to respond on a five point Likert scale to 10 Likert statements presented in a random order. In five pairs of diametrically opposed statements, the following five subject areas were interrogated;

1. Quality performance
2. Cost Certainty
3. Management Cost
4. Overall Non-Cost Performance
5. Health, Safety and Environmental Performance

A summary of the results from this section of questions are presented in Table 27 (Page 56) and are represented visually in Figure 28 (Page 57).

7.2.1. Quality Performance

Participants were asked to respond to two opposing statements regarding the quality of work delivered by subcontractors compared to internally delivered work. In both cases a neutral response was the most common, with little difference in perceived effect between the opposing statements across all delivery teams.

Differences in the perceived effect on quality were observed in the comments of those respondent who did not respond neutrally. This divergence in opinion is summarised particularly well by two respondent's comments. A Manager from delivery team D stated: *"some of our subcontractors have staff who were very new to the industry, this leads to potential quality issues".* While a Site Engineer from delivery team C suggested the opposite. *"When managing a subcontractor you are able to focus on quality and safety issues rather than productivity as well".*

7.2.2. Cost Certainty

Respondents were asked to respond to two opposing statements regarding the certainty of final costs of work delivered by subcontractors compared to internally delivered work. The results clearly show a perceived increase in cost certainty when using subcontractors. 64% of respondents either agreed or strongly agreed that cost certainty increases when tasks are subcontracted, and conversely 61% disagreed that cost certainty would decrease.

7.2.3. Management Cost

Participants were asked to respond to two opposing statements regarding the effect on cost of management when utilising subcontractors compared to internally delivered work. The results clearly show a perceived decrease in management cost when using subcontractors. Management cost decrease was the highest ranked effect of engaging a subcontractor. 79% of respondents recorded either agree or strongly agree with the statement 'When using subcontractors management costs decrease' (Table 27, pg. 56).

One participant claimed that "*Using subcontractors decreases internal management costs"* and then qualified that statement by claiming that the overall cost of the task would be higher due to subcontractor P&G.

7.2.4. Overall non-cost Performance

Participants were asked to respond to two opposing statements regarding the Overall non-cost Performance of work delivered by subcontractors compared to internally delivered work. In both cases a neutral response was the most common. However, an indication towards non-cost performance increasing when utilising subcontractors was observed.

7.2.5. Health, Safety and Environmental Performance

Participants were asked to respond to two opposing statements regarding the risk of health safety or environmental incidents during work delivered by subcontractors compared to internally delivered work. The results clearly show a perceived increase in the risk of incidents occurring when using subcontractors.

One respondent emphasised that while there was a perceived increased risk of incidents effective management was key: "*On site management of subcontractors is key to minimising HSE incidents, subcontractors are more focused on productivity than quality and safety".*

7.3. Effect on project performance

Respondents were asked to judge the extent to which financial and non-cost project performance respectively were affected by the categorical variables introduced in section 4.2 (Page 23) using a Likert scale. A graphical summary of the responses is presented in Figure 30 (Page 59).

The majority of respondents considered all factors to have some level of impact on both financial and non-cost performance. Respondents ranked the location of a project within Christchurch to have the lowest effect of the variables. The time of a projects start was ranked most influential on KRA performance, and the delivery team most influential on financial performance. Subcontractor engagement was considered by respondents to be influential on both financial and no-cost performance, but was not ranked highly among other variables in either area.

Table 26: Motivations to engage subcontractors: A summary of responses to Likert scale questionnaire.

	Level of Agreement					Mean rating	Overall Rank
Statement	**Strongly Agree (1)**	**Agree (2)**	**Neutral (3)**	**Disagree (4)**	**Strongly Disagree (5)**		
Lack of internal resources (Staff or plant availability)	7	17	4	0	0	1.9	1
Subcontractors have a required specialist trade skill / item of plant	7	18	2	1	0	1.9	1
Lack of internal expertise/ability	4	16	6	2	0	2.2	3
Provides flexibility to meet changing labour demands	5	18	0	4	1	2.2	3
Engaging a subcontractor reduces financial risk	4	12	9	2	1	2.4	5
Internal delivery presents unwanted financial risk	4	13	6	4	1	2.5	6
Subcontracting is less costly than delivering internally	2	11	10	5	0	2.6	7
Subcontractors perform work faster	3	8	12	4	1	2.7	8
Subcontractors easier to manage than internal resource	2	9	13	3	1	2.7	8
Provides cost certainty of task subcontracted	0	13	10	5	0	2.7	8
Internal delivery is more expensive	0	5	13	10	0	3.2	11

Table 27: Effects of engaging subcontractors over internal resources: A summary of responses to Likert scale questionnaire.

Statement		Level of Agreement					Mean rating	Overall Rank
		Strongly Agree (1)	**Agree (2)**	**Neutral (3)**	**Disagree (4)**	**Strongly Disagree (5)**		
Quality of work delivered by subcontractors is:	Likely to be better	0	8	13	7	0	3.0	6
	Likely to be worse	3	7	10	7	1	2.9	5
The costs of tasks subcontracted is:	Likely to be Certain	3	15	5	5	0	2.4	2
	Likely to be Uncertain	0	4	7	14	3	3.6	7
When using subcontractors management costs:	Increase	0	2	10	13	3	3.6	8
	Decrease	6	16	5	0	1	2.1	1
When using subcontractors, non-cost performance is:	Worse	0	1	12	12	3	3.6	8
	Better	0	10	13	5	0	2.8	4
When using subcontractors, the risk of health safety or environmental incidents :	Decrease	0	0	6	14	8	4.1	10
	Increase	3	11	9	5	0	2.6	3

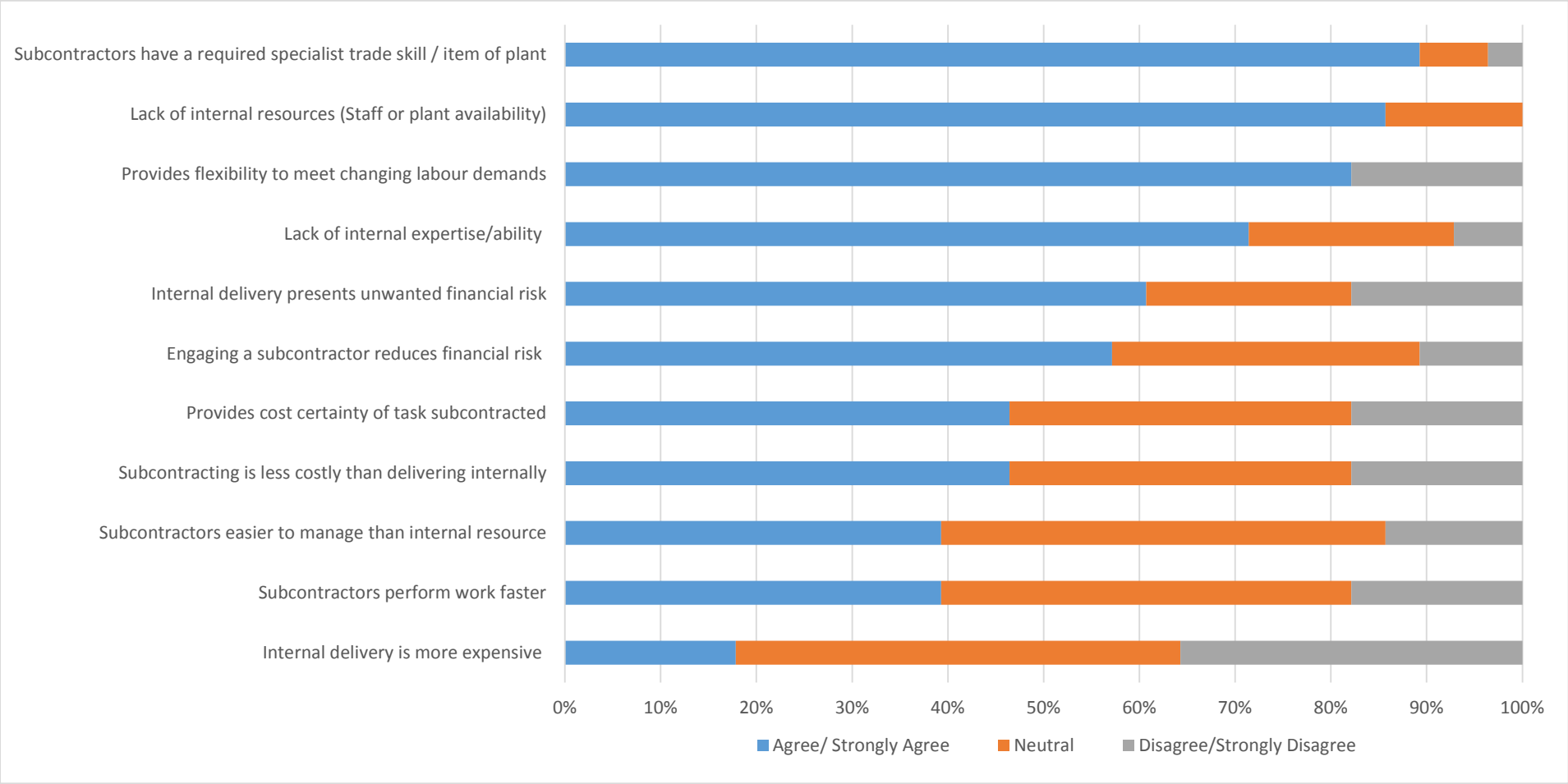

Figure 28: Motivations to engage subcontractors: A summary of responses to Likert scale questionnaire.

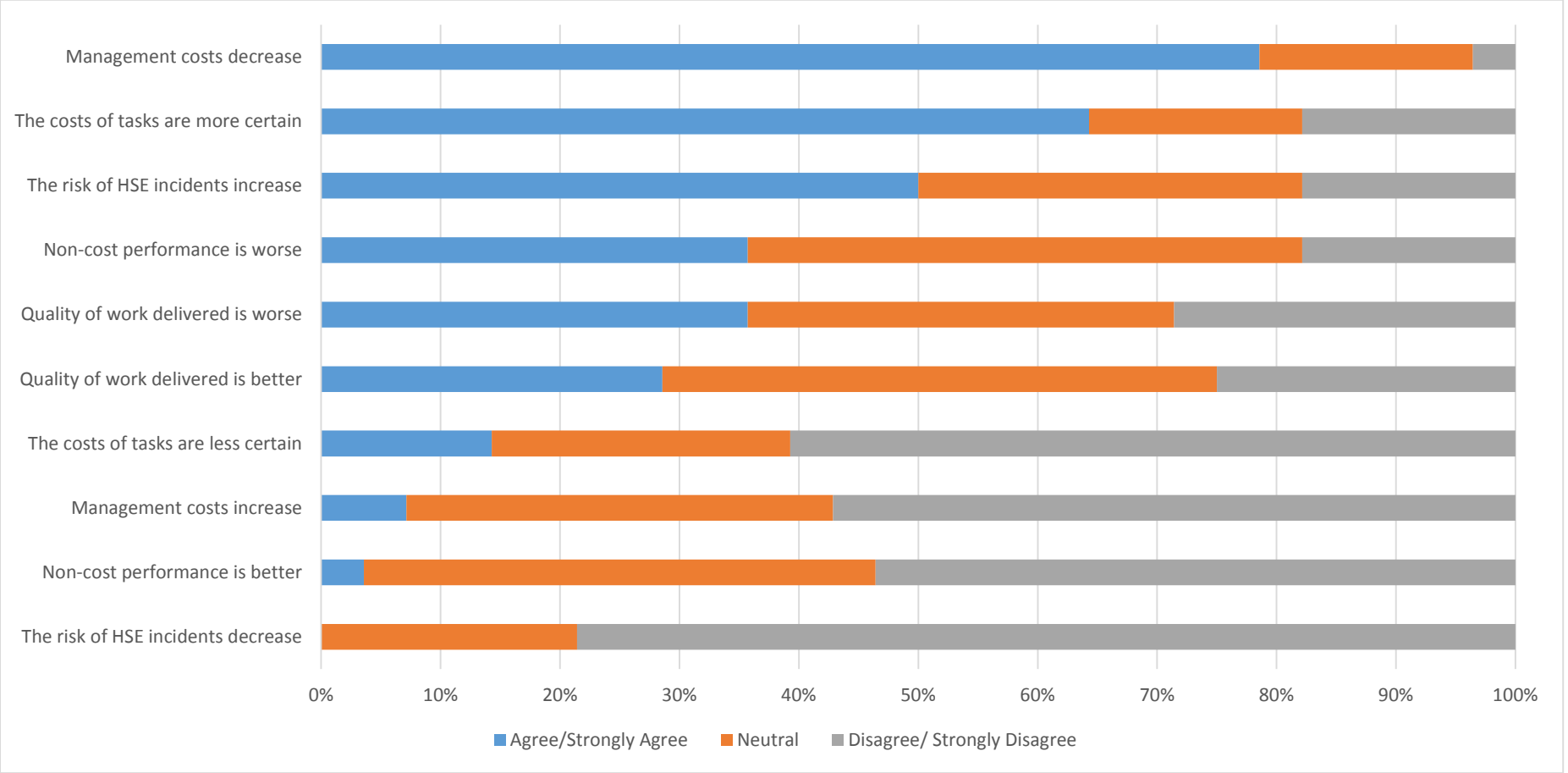

Figure 29: Effects of engaging subcontractors over internal resources: A summary of responses to Likert scale questionnaire.

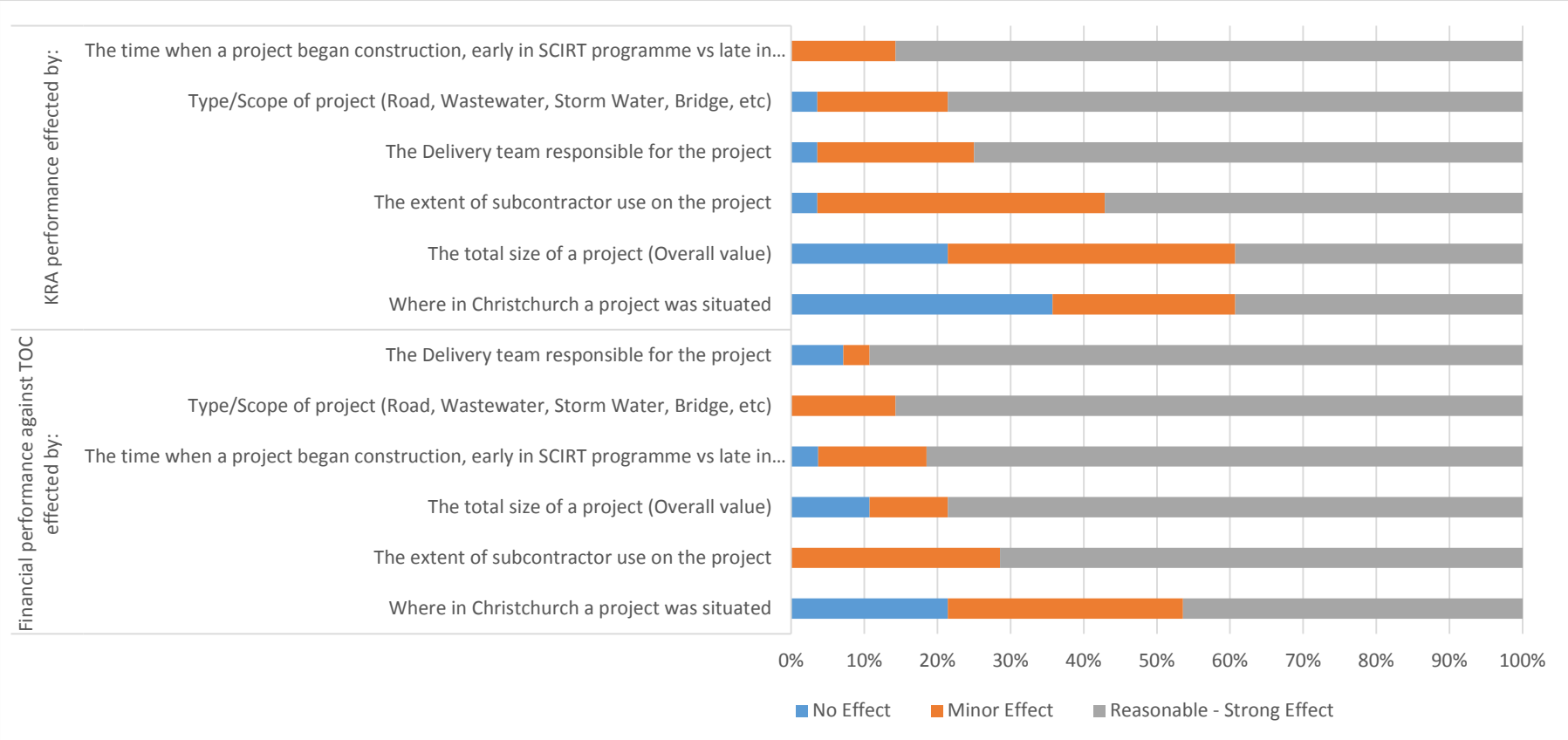

Figure 30: Factors effecting overall Project performance in SCIRT: A summary of responses to Likert-type scale questionnaire.

8. DISCUSSION

In this section the results of the study are discussed in the context of the original research objectives and questions. The motivation to engage subcontractors is examined with respect to the three key areas of ability, flexibility, and cost. Then a review of the subcontracting strategies observed in the SCIRT alliance is completed, and the effects of these chosen strategies of financial performance non-cost performance measures are discussed.

8.1. Motivations of principal contractors to subcontract work sections within SCIRT

A review of the literature (section 2.2, page 6) suggested the reasoning for a reliance on subcontractors in the general construction industry is based on three key points: Ability, Flexibility and Cost. This reasoning posits that subcontractors either; possess specialist trade skills or equipment; Provide flexible capacity to meet the changing labour demands; and/or perform distinct tasks at a cheaper rate- providing overall cost certainty. This study therefore, sought to confirm the importance of these factors.

8.1.1. Ability

Principal contractors (delivery teams) within SCIRT were found to engage subcontractors primarily to meet project resourcing requirements that were unable to be met internally. The requirement for a specialist item of plant or specialist skill was the highest ranked motivating factor for engaging a subcontractor. This aligns directly with the 'ability' factor presented in the general construction industry.

In the context of SCIRT an example of such a specialist task is pipe lining - a trenchless pipe rehabilitation technology which remediates broken or cracked sewer pipes to strengthen and mitigate groundwater penetration and root intrusion. This a specialist task that involves unique equipment and experienced staff. Prior to the earthquakes there was very little demand for this technology in Christchurch and majority of top tier civil contractors did not have internal capability in this area. In the aftermath of the earthquakes, demand for pipe lining increased as it was a cost effective solution. As a result, it was scheduled as part of many SCIRT projects. Demand for pipe lining subcontractors increased dramatically and all delivery teams engaged subcontractors to carry out this task. In this example, the subcontractor was engaged to provide a service that could not reasonably be provided internally by the delivery teams.

8.1.2. Flexibility

The second highest ranked motivating factor to engage subcontractors was their ability to resolve short term shortages in labour. The volume of work in the SCIRT programme required a large increase in local labour force. A short term increase in labour demand was viewed as a risk to the longevity of a large contractor, increasing capacity to meet the demand may result in excess staff at the end of the project. Although delivery team staff numbers did increase to fulfil the Alliance contract, much of the labour demand was met by subcontractors. Many small to medium subcontractors with bases outside the Canterbury region established themselves in Canterbury post-earthquake to capitalise on this demand and increased work volume. As demand dropped from its peak many of those subcontractors have now left the region (Wilkinson & Yan Chang-Richards, 2016).

Whilst the delivery teams all had some presence in Christchurch, some had more local resources and staff than others. In particular, Fulton Hogan, Downer and City Care were established civil maintenance contractors who held contracts with local and central government authorities in the region at the time of the earthquakes. Fletcher Construction and McConnell Dowell had interests in the Canterbury construction market but lacked the same extent of labour and resource as the other delivery teams. Those delivery teams with a less accessible local resource relied more heavily on subcontractors to resource their work as a result.

8.1.3. Cost

Project Managers in SCIRT engaged subcontractors where they were able to perform at or below the rates allowed for in the project TOC. The risk of cost overrun and poor productivity, was a motivating factor to engage a subcontractor. Over 60% of managers questioned agreed that internal delivery presented a financial risk. These managers view subcontracting with fixed rates as a way to gain cost certainty rather than an opportunity to complete work at a cheaper rate than what is attainable with internal resources.

Improved project financial or non-cost performance was not ranked highly as a motivating factor by delivery teams. Less than half of those delivery team employees questioned agreed that a subcontractor's ability to perform the work cheaper than internal resources was a motivating factor toward engaging with them. Many managers commented that in SCIRT cost was not as much a consideration as the quality and timely completion of a project. With the volume of work

stretching available internal resources, subcontractors were engaged to meet the resource shortage at any acceptable cost, generally without extensive bid-shopping.

8.2. Subcontracting Strategies Observed in the SCIRT alliance

During SCIRT, all delivery teams did not utilise subcontractors to the same extent. Between the five delivery teams there appears to be three different strategies employed – 1) external delivery strategy, 2) balanced delivery strategy and 3) internal delivery strategy (Table 28).

Table 28: Different observed subcontracting strategies in SCIRT

Strategy	Description	External Cost Proportion	Delivery Team	Observed sample mean project external Cost Proportion
External	Subcontract as much as possible all physical works. Retain Internal technical and project management functions.	75%-65%	A	69%
			C	75%
Balanced	Utilise internal resources in existing core business areas. Utilise subcontractors where there is no internal capacity.	60%-50%	B	52%
			D	53%
Internal	Self-perform where at all possible. Recruit skills if necessary. Use subcontractors for only specialised tasks.	40%-30%	E	35%

Two delivery teams (A & C) utilised an external delivery strategy – where subcontractors were engaged to deliver the vast majority of physical works. In this strategy, the delivery team retains only the key project management and supervisory functions to coordinate and monitor the progress of physical works. Subcontractors are utilised where at all possible and engaged through a variety of contractual mechanisms, tendered measure and value rates,

Two delivery teams (B & D) utilised a balanced delivery strategy. In this strategy existing internal resources are used to perform work that is within the delivery team's core area of business, and subcontractors are used to deliver outside their expertise or to meet internal resource shortages.

One Delivery team (E) utilised an internal delivery strategy, where at all possible physical works were performed internally. Skilled staff are recruited and necessary plant are procured to make delivery feasible. Subcontractors were engaged for specialist tasks when the use of internal resources was not practical, or the alliance requirement of 40% subcontracted cost was required.

8.2.1. Minimum requirement

During the course of the Alliance delivery teams were able to choose how the work allocated to them was delivered - with the exception of one requirement: A minimum of 40% of the work completed, by cost, must be subcontracted (Christchurch Infrastructure Alliance , 2011). This requirement was included as part of the Alliance agreement to foster a competitive local construction market and encourage local business development.

Only one delivery team utilised subcontractors at the specified minimum requirement. All other teams chose to utilise subcontractors significantly more than the minimum. It is possible to conclude then, assuming all delivery teams acted in self-interest to maximise the margin available, the chosen delivery strategy was either not perceived to affect margin or delivery teams had unique internal drivers for the strategy employed.

8.2.2. Motivation to use different subcontracting strategies

It is curious that in an Alliance environment, where communications and learnings were readily shared between delivery teams, that subcontracting strategy differed so significantly, and that one optimum strategy was not arrived upon. The aggregated commentary received during this research indicates there are multiple factors that may explain this observed difference in subcontracting strategy between delivery teams.

Above all, the extent of locally available internal resources is the critical factor in the decision to engage a subcontractor. A firm with large local internal resource base is required by its situation to utilise these internal staff - or carry their cost burden. Before engaging a subcontractor, all available internal staff must be fully utilised. Conversely, as discussed in section 8.1.2 (page 61) those delivery teams with a less accessible local resource relied more heavily on subcontractors to resource their work as a result. Principal contractors with an existing large local labour base will inevitably tend toward an internal delivery strategy. Unless the scope of work is outside the skill set of the existing labour base – in which case a suitable subcontractor would be sought and alternative work must be found for the local labour base

Commentary from managers indicates there may also be different opinions on risk management approaches between delivery teams. Multiple managers from delivery teams utilising balanced strategies commented that the utilisation of internal resources allows the project manager to capitalise on risks and derive a financial benefit through effective project management. Whereas subcontract rates for similar tasks will generally include an allowance for risk, and the principal will incur this cost regardless of whether or not the risks eventuates. Principal contractors looking to derive a financial benefit from proactive risk management will likely tend toward an internal delivery strategy, however this requires skilled project management.

Multiple managers commented that the limb payment system incentivised the use of internal plant, this presents a further factor that may explain the differing choice of delivery strategy. Managers commented that delivery teams were effectively able to guarantee adequate plant hours to warrant the procurement of plant items. Although the agreed plant cost rates within SCIRT were audited regularly and aligned with industry standard, an opportunity may have existed for delivery teams to facilitate optimum cost recovery on plant and derive a financial return through the provision of plant at an actual cost lower than the agreed rate. This derived return, may have offset any cost overrun or 'pain' experienced in the even that TOC was exceeded. It was hypothesised by SCIRT staff that this situation incentivised internal delivery and enabled the expansion of existing internal resource. Investigation of this scenario was outside the scope of this research – but would be necessary to completely understand the motivation to deliver with internal resource.

8.3. Correlation between subcontractor engagement and financial performance

Within the New Zealand civil contracting industry, there is a commonly held opinion that the utilisation of subcontractor rates in competitively tendered work renders a tender less competitive. There is a perception that the profit margin allowed within the subcontractors pricing, and the profit margin allowed by the principal, will compound to result in an un-competitive price. If this notion were to be founded, then one may expect to observe in SCIRT an increased ultimate cost of delivery as subcontractor utilisation increases. However, this study has been unable to observe any such significant trend. On the contrary, the study indicates the opposite trend. In the sample data analysed, increased subcontractor usage correlates with better overall financial performance.

The positive correlation between subcontract use and financial performance is weak and has low statistical significance. However, observing a more statistically significant result may be particularly difficult due to the limitation of having only five observable delivery teams. Significant differences in the extent of subcontractor use were found across; value, scope and location sub-categories. However, in none of these categories was a significant difference in financial performance observed. As the SCIRT programme progressed an improvement in financial performance was observed as the SCIRT programme

Dissemination of the commentary provided by delivery team personnel who had influence over the management of, or decision to use (or not to use), subcontractors within SCIRT posits three possible rationalisations that may explain this result:

8.3.1. Cost certainty through subcontract procurement

Where at all possible, delivery teams do not engage subcontractors at rates that exceed the productivity and cost assumptions used to formulate the TOC estimate. Subcontractors are engaged through measure and value or lump-sum procurement arrangements where cost certainty for the principal is attained. This is in contrast to the cost reimbursable basis of payment utilised for delivery teams – where productivity risks remain with the delivery team.

8.3.2. Separation of responsibility for productivity

In an internal delivery strategy, responsibility for meeting required productivity targets rest with the project management and supervision personnel. These same personnel are also, in this scenario, responsible for many other considerations, for example; safety management, project staff line management, and quality management. The procurement of subcontractors to perform the physical works, clearly separates project management staff from productivity concern and allows more focus on other these other considerations. Utilising an internal delivery strategy – productivity may come at the expense of increased safety and quality concerns.

8.3.3. Financial motivation cascade

Where comparatively small subcontract firms are used, it is common for majority shareholders in the firm to be heavily involved in the physical works. Subcontract firm owners in SCIRT were observed in site supervision and management capacity, or in many cases providing direct site leadership. For these small firms the success or failure to meet productivity targets on an

individual project may have a large impact on the firms overall profitability and a majority shareholder managing the work is likely to be directly motivated to ensure these targets are met.

8.4. Subcontract procurement for productivity

The limb payment mechanisms (Section 2.6.4, page 12) utilised in SCIRT may have affected a delivery team's decisions to engage subcontractors over using internal resources. Internal costs were charged independently of construction progress, through the cost reimbursable contract format. Conversely, in many cases subcontracts could be procured with a measure and value contract facility - meaning subcontractors could be paid by work completed, rather than by the time taken / actual costs incurred. This procurement methodology can effectively transfer the productivity risk from the principal to the subcontractor by creating a direct financial incentive for improved performance.

As discussed in section 2.4 (pg. 7), one core driver behind the use of relational and alliance style contracts is to remove uncertainty and risk from the client-contractor relationship, and to enable both parties to share any benefits (or losses) that this collaboration may result in. It is significant then, that when given opportunity to do so, many contractors rely on a traditional-style subcontracts to deliver work. As a result, the uncertainty (which the original procurement model sought to avoid) is transferred to the non-alliance participants. It is reasonable then, to hypothesise that procurement style may have a causal effect on financial performance.

If so, there is potential that the positive relationship between subcontracting and financial performance indicated by this study may be due to financial efficiency gained by employing traditional (non-relational) contracts.

As with SCIRT, overall uncertainty of project scope and need to deliver rapidly are further drivers to use relational forms of contract in disaster response works. The time and cost needed to adequately prepare a formal contract between public clients and principal construction contractors is often undesirable. However, as shown in SCIRT, principal contractors are clearly able to form formal subcontracts with acceptable costs and time resources. Perhaps, without the need to adhere to public procurement and transparency regulations, principals can divide the work and engage a subcontract firms with efficiency and speed not attainable by public authorities.

8.5. Correlation between subcontractor engagement and non-cost performance

A negative relationship between subcontractor engagement and non-cost performance was observed in the sample data analysed. Non-cost performance was measured as the monthly KRA score, of which Quality, Safety and Environmental performance are key inputs. The negative correlation of subcontractor engagement and non-cost performance result is generally expected among project management professionals.

A common theme in project management literature discusses the interplay between the triple constraints of cost, quality and time in any given project (Project Management Institute, 2013). The theory posits that it is not possible to optimise all three constraints, and that the optimisation of two of these constraints will negatively impact the third. In the context of this research, utilising subcontractors can effectively control cost and productivity (time) constraints, if procured correctly. Then, it could be expected by way of the triple constraint theory - that quality considerations would be negatively affected as subcontractor engagement increases.

The observed negative relationship between quality and subcontractor engagement was also expected, to some degree, by delivery team personnel questioned for this research. In comparison to internal delivery, respondents ranked an increase in health and safety incidents when using subcontractors the third highest effect behind a decrease in management and increased cost certainty. Also, delivery teams that employed a balanced or internal delivery strategy considered that quality was likely to be negatively affected by the extent of subcontractor engagement.

An external delivery strategy aims to utilise subcontract procurement functions to control time and cost constraints and focus internal resource on the monitoring and controlling quality (KRA) and scope. In the context of the SCIRT Alliance the quality constraint encompasses all KRA performance areas. An internal strategy must therefore employ a more rigorous project management plan as internal resources will be expected to balance time, cost and quality without the aid of a subcontract procurement facility.

8.6. Internal subcontractors and relational subcontracts

Some project managers commented on the use of ‘internal subcontractors’ in delivering SCIRT projects. Several delivery teams appear to use a departmental organisational structure in which

project managers are able to draw on specific internal resources to deliver work. For example; the internal road surfacing department may supply asphalt surfacing for a roading project – but have no other interaction with the other construction tasks in project. In effect, the department is treated the same as a subcontractor. However, there are key differences between utilising internal and external subcontractors, critically the three rationalisation for improved financial performance discussed in section 8.3 (pg. 64) do not apply to internal subcontractors;

1) Cost certainty through procurement; in an alliance environment where actual costs are charged directly to the project, without a formal contract to separate financial responsibility, cost certainty is unable to be achieved.
2) Separation of responsibility for productivity; As there is no formal subcontract to remove the financial risk for the task from the project management team the act of engaging an 'internal subcontractor' does not remove the requirement to actively manage construction productivity.
3) Financial motivation cascade; In an internal subcontracting scenario both the internal department and the project management team experience the same level of personal financial incentive to increase performance, where typically no persons involved in the project delivery are significant shareholders in the delivery firm.

In order to provide effective insulation from cost and productivity concerns, the Principal-Subcontractor relationship must take the form of a traditional contract. In situations where a relational/alliance contract exists between the Principal and the Client, a similar relational contract form for a subcontract is typically unable to provide effective separation from cost and productivity concerns. As exemplified in the case of an internal subcontractor, direct responsibility for cost, and consequence for cost overrun is required to rationalise a positive correlation between subcontractor usage and financial performance.

9. CONCLUSIONS AND RECOMMENDATIONS

This chapter presents conclusions of this study, and describes the contribution made to the existing body of knowledge on subcontractor use in civil construction. Recommendations for further research in this area are also presented.

9.1. Conclusions

Motivations for the use of subcontractors in the delivery of the SCIRT Alliance contract are based on three factors: Ability, Flexibility and Cost. Principal contractors engage with subcontractors because they; possess specialist trade skills or equipment; Provide flexible capacity to meet the changing labour demands; and/or perform distinct tasks at a cheaper rate- providing overall cost certainty.

In SCIRT there are clear differences in the extent to which subcontractors were utilised by principal contractors. Presented with similar project scope in the same contractual environment, principal contractors independently chose to utilise subcontractors to different extents. The subcontracting strategies observed in SCIRT can be presented in three broad categories;

1) Internal Delivery – work is performed predominantly by internal resources.
2) Balanced Delivery – work is performed by subcontractors where internal resource is unable.
3) External Delivery – the majority of work is performed by subcontractors.

Analysis in this study suggests that a positive correlation exists between subcontractor engagement and overall financial performance. Principal contractors that utilised an external delivery strategy exhibited better financial performance than the other principal contractors. This trend may be explained by the ability for a subcontract to; provide cost certainty, separate productivity from other conflicting priorities, and cascade financial performance incentives closer to the physical work being performed.

A negative correlation was observed between subcontractor engagement and non-financial performance. Increased subcontractor engagement was correlated with reduced performance in quality, safety, environmental and other non-cost key result areas. This can be explained by the triple constrain theorem whereby the optimisation of productivity (time and cost constraints) negatively impacts non-cost performance (quality constraint).

9.2. Contribution to knowledge

The theoretical benefits of engaging subcontractors in general construction are well documented, however the actual experience and effect of subcontractor use in the civil construction industry is largely absent from literature. This work has used an analytical, data driven approach to observe correlations between subcontractor engagement and performance that, for the most part, support the theoretical benefits and drawbacks of using subcontracts presented in literature.

This work serves to provide business leaders within the New Zealand civil construction industry empirical evidence of the effects of subcontractor engagement in a relational contracting environment. With this knowledge, it is hoped that more informed opinions about the relative merits and drawbacks of subcontractor engagement are held within the industry.

9.3. Recommendations for future research

A link may exist between financial efficiency and the form of subcontracts used within a relational contract environment. This theory posits that in order to provide the necessary insulation from cost and productivity concerns, the Principal-Subcontractor relationship must take the form of a traditional contract. The contrast between a relational style head contract and traditional form of subcontract may derive an opportunity for improved financial performance.

Investigations should be made into situations where subcontractors are engaged on the same contractual terms as the principal contract. Where there is no observable improvement in performance with subcontractor engagement in this scenario, it may indicate that any efficiency gains are due to traditional contract forms.

Further to this, an investigation of the payment system used in SCIRT to ascertain whether the system incentivised the use of internal plant. The results of such an investigation could be used to ensure that future alliance contract payment systems incentivise best value construction.

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11.APPENDICES

Appendix 1. Regression Tables

Table 29: Linear regression using total expenditure on subcontractors to predict overall sample performance against TOC.

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.738	.545	.393	.069

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.017	1	.017	3.588	.155[b]
	Residual	.014	3	.005		
	Total	.032	4			

a. Dependent Variable: % Spent of TOC Sum

b. Predictors: (Constant), % Total Spend on Subcontractors

Regression Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.320	.164		8.028	.004
	% Total Spend on Subcontractors	-.492	.260	-.738	-1.894	.155

a. Dependent Variable: % Spent of TOC Sum

Table 30: Regression model to predict Relative Non-cost Performance using the proportion of subcontracted hours worked each month and delivery team.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1640.606a	5	328.121	49.245	.000
Intercept	168.842	1	168.842	25.340	.000
Delivery Team * Sub %	1620.109	4	405.027	60.788	.000
Sub %	213.767	1	213.767	32.083	.000
Error	1092.731	164	6.663		
Total	2733.337	170			
Corrected Total	2733.337	169			

a. R Squared = .600 (Adjusted R Squared = .588)

Appendix 2. Non-disclosure agreement

Research and Innovation

MUTUAL CONFIDENTIALITY AGREEMENT

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

DATE: 14-3-16

PARTIES: **University of Canterbury** at Christchurch

AND
SCIRT
1 Magdala Place
Middleton
Christchurch

BACKGROUND:

A. The parties have, and will in future exchange or provide to the other certain confidential and commercially sensitive information.

B. The parties intend that they will each have the same and reciprocal rights and obligations with respect to Confidential Information that is disclosed to or received by the other (respectively).

C. This Agreement sets out the terms and conditions on which the parties will disclose and agree to use such information.

D. The purpose of the provision of confidential information between the parties is to facilitate the publication of a thesis that will disseminate learnings from the SCIRT alliance contract (altogether called "the Purpose").

TERMS

1. Definitions and Interpretation

1.1 **Definitions**: In this Agreement the following terms shall have the meanings specified:

Confidential Information — All information disclosed by one party to the other, whether in the past relating, or in the future, for or incidental to the Purpose and includes but is not limited to all Intellectual Property of either party and any information:

(a) Relating directly or indirectly to research or development by, accounting for, or the science, business affairs or financial, commercial or professional arrangements of either party, its customers, suppliers or business partners;

(b) Disclosed by either party to the other on the express basis that the Information is confidential; and

(c) Disclosed by either party to the other where the other party would reasonably be expected to retain the information as "Confidential".

Intellectual Property All intellectual property as that term is generally understood, whether registered or unregistered and includes but is not limited to any trade marks, trade secrets, copyright, designs, rights in computer software, databases and lists, rights in any inventions, technology, experimental methods and results (including physical, mechanical, chemical, biological, pre-clinical and clinical data), biological materials, genes, promoters, processes, systems, concepts, protocols, techniques, ideas and know-how of any nature (including, without limitation, all patents and patent applications), data in any format (including any raw data), drawings, assays, descriptions, business strategies and financial information, business and scientific plans, records, depictions, laboratory notebooks, computer programs and software, reports, and any other written, printed or electronically stored material.

1.2 **Interpretation**: In the interpretation of this Agreement, unless the context otherwise requires:

1.2.1 References to the parties include their respective successors and permitted assigns;

1.2.2 References to any person includes any individual, company, corporation, firm, partnership, joint venture, association, trust, state or agency of state, government department or local or municipal authority in each case whether or not having a separate legal personality;

1.2.3 Words in the singular shall include the plural and vice versa;

1.2.4 Any obligation not to do anything includes an obligation not to suffer, permit or cause that thing to be done;

1.2.5 Headings have been inserted for convenience only and shall not affect the construction of this Agreement;

1.2.6 References to clauses and schedules shall be construed as references to the same in this Agreement.

2. Prohibition on Disclosure

2.1 Each party shall maintain as confidential and shall not at any time, directly or indirectly:

2.1.1 Disclose, or permit to be disclosed to any person;

2.1.2 Copy; or

2.1.3 Use for itself or for the benefit of any person other than the other party; or

2.1.4 Use to the detriment of the other party,

any Confidential Information belonging to the other party, except:

2.1.5 As is already or becomes public knowledge, otherwise than as a result of a breach by the party disclosing or using that Confidential Information of any provision of this Agreement, or as the result of a breach by any other person of any similar confidentiality obligation it owes to the other party;

2.1.6 As authorised in writing by the party to whom the Confidential Information belongs and then only on the terms, if any, specified in such written authority;

2.2 Notwithstanding clause 2.1 either party may disclose Confidential Information belonging to the other party strictly on a "need to know" basis to such of its officers, employees, affiliates, consultants or professional advisers as is reasonably necessary in order to give effect to the Purpose, provided that it:

2.2.1 Has first advised such officer, employee, affiliate, consultant or professional adviser of the confidential nature of the Confidential Information; and

2.2.2 Ensures such officer, employee, affiliate, consultant or professional adviser is subject to confidentiality obligations in respect of that Confidential Information that create equivalent duties of confidentiality and non use and are no less onerous than the obligations set out in this Agreement.

2.3 Each party acknowledges that any subsequent unauthorised disclosure or use of any Confidential Information by its employees, affiliates, consultants or advisers shall be deemed to be a disclosure or use by it in breach of this Agreement.

2.4 Each party shall:

2.4.1 Take all necessary and reasonable steps (including but not limited to all reasonable security measures) to prevent any Confidential Information from being disclosed to any person not authorised to receive it under this Agreement;

2.4.2 Not use the Confidential Information for any purpose other than the Purpose;

2.4.3 Immediately inform the other party, and provide all reasonable assistance in relation thereto, if it becomes aware of the possession, use or knowledge of any Confidential Information by any person not authorised to possess, use or have knowledge of that Confidential Information under this Agreement;

2.4.4 As soon as reasonably possible upon receipt of written notice from the party which has disclosed Confidential Information to it, and to the extent requested by that party in that notice cease to use, and at the option of that party, return to that party or destroy all written material or other storage media containing, referring to or arising out of any Confidential Information supplied under this Agreement.

2.5 If either party (the First Party) is required by law to disclose any Confidential Information belonging to the other party, the First Party will immediately notify the other party that such requirement to disclose has arisen. The First Party will where permitted, allow the other party a reasonable opportunity, on the First Party's behalf and at the other party's cost (unless the disclosure is required as a result of the First Party breaching its obligations under this Agreement), to take any lawful action intended to restrict or prevent the disclosure of that Confidential Information. If the other party's attempt to prevent disclosure is unsuccessful, the First Party shall:

2.5.1 Only furnish that portion of the Confidential Information which it is advised by written opinion of counsel is legally required to be disclosed; and

2.5.2 Exercise its best efforts to co-operate with the other party in obtaining assurances that confidential treatment will be accorded to that portion of the Confidential Information required to be disclosed.

2.5.3 In the case where a party that has received Confidential Information is uncertain whether or not the disclosure or publication of any information would or might reasonably breach the obligations of confidence arising under this Agreement, that party agrees to obtain prior written clearance from the party which disclosed the Confidential Information to it.

2.6 The parties acknowledge that Confidential Information may have been provided by the one party to the other party prior to the date of this agreement for the Purpose, in the expectation that such information was or is confidential, and they agree that the provision of further Confidential Information from that party to the other party will be valuable consideration for the party receiving the Confidential Information to agree to keep all previous information which has been supplied to it, confidential in terms of this agreement (together with all additional Confidential Information to be supplied to that party in future), to the same extent as if the parties had entered into this agreement before any information relating to the project was supplied.

2.7 Nothing in this agreement shall require any party to maintain confidentiality in respect of Confidential Information which is the property of that party.

3. Breach

3.1 The parties agree that monetary damages will not be a sufficient remedy for any breach of this Agreement. In the event of a breach or anticipated breach of any of the terms of this Agreement by the party which has received Confidential Information ("the First Party") or any of its employees servants or agents the other party may, in addition to any other rights or remedies available to it, exercise all or any of the following rights and remedies:

3.1.1 sue for an injunction;

3.1.2 obtain full reimbursement for losses, damages, claims, costs, expenses, liabilities, proceedings and demands which the it may incur or suffer as the result of any unauthorised disclosure or use of the Confidential Information by the First Party;

3.1.3 obtain an account for any profit made by the First Party or any other person firm or company in utilising the Confidential Information;

3.1.4 obtain full reimbursement of all costs and expenses (including on a solicitor/client basis) incurred in enforcing the provisions of this Agreement;

3.2 If the First Party becomes aware of any legal requirement or pending legal requirement to disclose any Confidential Information provided to it by the other party, the First Party must forthwith and with all due haste advise the other party of such requirement and provide full assistance and co-operation to the other party to enable it to seek appropriate protective orders or other remedies or actions to resist, narrow or prevent the scope of such requirement or legal process, or to waive compliance by the other party, in whole or in part, under the terms of this Agreement. The First Party will not oppose any action of the other party in seeking a protective order or other appropriate remedy. In the event that no such protective order or other remedy is obtained, or the other party waives compliance with the terms of this Agreement, the First Party may disclose only that part of the information that is advised by legal counsel for the other party in writing as legally required. In any such event the First Party shall use its best endeavours to ensure that all information so disclosed will be subject to duties of confidence in favour of the other party.

4. Other Agreements

4.1 Both parties' obligations in respect of the Confidential Information shall be in addition to any other obligation under any other agreement which involves the Confidential Information, unless expressly excluded by reference.

5. Indemnity

Each party agrees to indemnify and keep the other indemnified and harmless from any damages, losses, costs, or liabilities (including, without limitation, legal fees or other costs of enforcing this indemnity) arising out of or resulting from any unauthorised use or disclosure by party receiving Confidential Information ("the Receiving Party") or any persons to whom the Confidential Information has been disclosed by the Receiving Party or any violation of the terms of this Agreement.

6. Rights to Confidential Information

6.1 Each party reserves all rights in its Confidential Information and no rights or obligations other than those expressly referred to, are granted or to be implied from this Agreement. Without limiting the foregoing, the disclosure by a party of any Confidential Information shall not amount to, or imply, the grant to the other party of:

6.1.1 A licence to that Confidential Information for any purpose other than the Purpose; or

6.1.2 Any right, title or interest in or to any intellectual property rights or proprietary rights of the first party in the Confidential Information.

6.2 Each party shall, as soon as reasonably possible upon receipt of written notice from the other party, and to the extent requested by the other party in that notice cease to use, and either return to the other party or destroy all written material or other storage media containing, referring to or arising out of any Confidential Information belonging to that other party supplied under this Agreement.

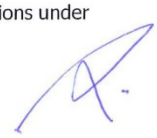
7. General

7.1 The failure or delay of a party to insist in any one or more instances upon a strict performance of any of the terms of this Agreement, or the waiver by a party of any term or right under this Agreement or of any default of the other party, shall not be deemed or construed as a permanent waiver thereof or of any other term, right or default or operate to bar the enforcement or exercise of any term or right in any other instance at any time or times thereafter.

7.2 This Agreement may be executed in any number of counterparts (including facsimile copies or other electronic copies) all of which, when taken together, shall constitute one and the same instrument. A party may enter into this Agreement by executing any counterpart. The parties acknowledge that this Agreement may be executed on the basis of an exchange of facsimile copies or other electronic copies and confirm that their respective execution of this Agreement by such means shall be a valid and sufficient execution.

7.3 This Agreement is governed by the laws of New Zealand and the parties submit to the exclusive jurisdiction of the New Zealand courts in respect of all matters relating to this Agreement.

7.4 Subject to any contrary written agreement between the parties, each party's obligations under this Agreement in relation to any Confidential Information are unlimited in time.



EXECUTED by the parties as an Agreement:

SIGNED on behalf of **UNIVERSITY OF CANTERBURY** by:

Signature: _____ Witness: C. Ansley.

Name/Title: Simon Tett Name: Clare Ansley

Date: 14-3-16 Address: Christchurch.

SIGNED on behalf of **SCIRT** by:

Signature: _____ Witness: _____

Name/Title: RS Cameron Value Manager Name: _____

Date 14/3/2016 Address: c/o SCIRT

Appendix 3. Example Survey Questionnaire

Subcontracting in SCIRT

A Study conducted by the University of Canterbury and SCIRT

* Required

1. **Name** *
   Record your full name (this information is confidential - all respondents will be kept anonymous)

2. **Phone Number**
   Record your Cellphone number

3. **What delivery team do/did you primarily work for** *
   Mark only one oval.
   - ◯ Downer
   - ◯ City Care
   - ◯ Fulton Hogan
   - ◯ Fletcher
   - ◯ McConnel Dowell
   - ◯ IST

4. **Role**
   What was/is your primary role in SCIRT
   Mark only one oval.
   - ◯ Site Engineer
   - ◯ Project Engineer
   - ◯ Project Manager
   - ◯ Senior Manager
   - ◯ Other:

5. **What year did you first become involved in SCIRT/IRMO**

Select the year
Mark only one oval.

- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016

6. **When did you leave SCIRT/IRMO**

Select the year
Mark only one oval.

- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016
- Still at SCIRT

Motivation

7. **Motivations to engage subcontractors** *

Mark only one oval per row.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Provides cost certainty of task subcontracted					
Engaging a subcontractor reduces financial risk					
Subcontractors have a required specialist trade skill / item of plant					
Internal delivery presents unwanted financial risk					
Subcontractors perform work faster					
Subcontracting is less costly than delivering internally					
Lack of internal expertise/ability					
Provides flexibility to meet changing labour demands					
Lack of internal resources (Staff or plant availability)					
Subcontractors easier to manage than internal resource					
Internal delivery is more expensive					

8. **Comment**
Please briefly comment on the differing motivations to use subcontractors within SCIRT.

Effects

9. **Effect of using subcontractors over internal resources** *
Mark only one oval per row.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Using subcontractors decreases management costs					
Using subcontractors increases management costs					
Quality of work delivered by subcontractors is likely to be worse					
Quality of work delivered by subcontractors is likely to be better					
Using subcontractors results in better KRA performance overall					
Using subcontractors provides cost certainty of tasks					
Subcontractors require less management than internal resource					
Using subcontractors increases the risk of health, safety or environmental incidents					
Using subcontractors results in worse KRA performance overall					
Using subcontractors decreases the risk of Health, safety or environmental incidents					

10. **Comment**
Please briefly comment on the effects of subcontractor use within SCIRT.

Other performance factors

11. **Financial performance against TOC effected by:** *

Indicate what effect you think the following had on financial performance of Projects
Mark only one oval per row.

	Strong Effect	Reasonable Effect	Minor Effect	No Effect
The total size of a project (Overall value)	◯	◯	◯	◯
The extent of subcontractor use on the project	◯	◯	◯	◯
The time when a project began construction, early in SCIRT programme vs late in programme	◯	◯	◯	◯
Where in Christchurch a project was situated	◯	◯	◯	◯
The Delivery team responsible for the project	◯	◯	◯	◯
Type/Scope of project (Road, Wastewater, Storm Water, Bridge, etc)	◯	◯	◯	◯

12. **KRA performance effected by:** *

Indicate what effect you think the following had on performance in Key Result Areas, (Safety, Environmental, Communications, etc)
Mark only one oval per row.

	Strong Effect	Reasonable Effect	Minor Effect	No Effect
Where in Christchurch a project was situated	◯	◯	◯	◯
The extent of subcontractor use on the project	◯	◯	◯	◯
The Delivery team responsible for the project	◯	◯	◯	◯
The time when a project began construction, early in SCIRT programme vs late in programme	◯	◯	◯	◯
The total size of a project (Overall value)	◯	◯	◯	◯
Type/Scope of project (Road, Wastewater, Storm Water, Bridge, etc)	◯	◯	◯	◯

13. **Comment**

Please briefly comment on the factors that influence SCIRT project performance (both KRAs and Financial)

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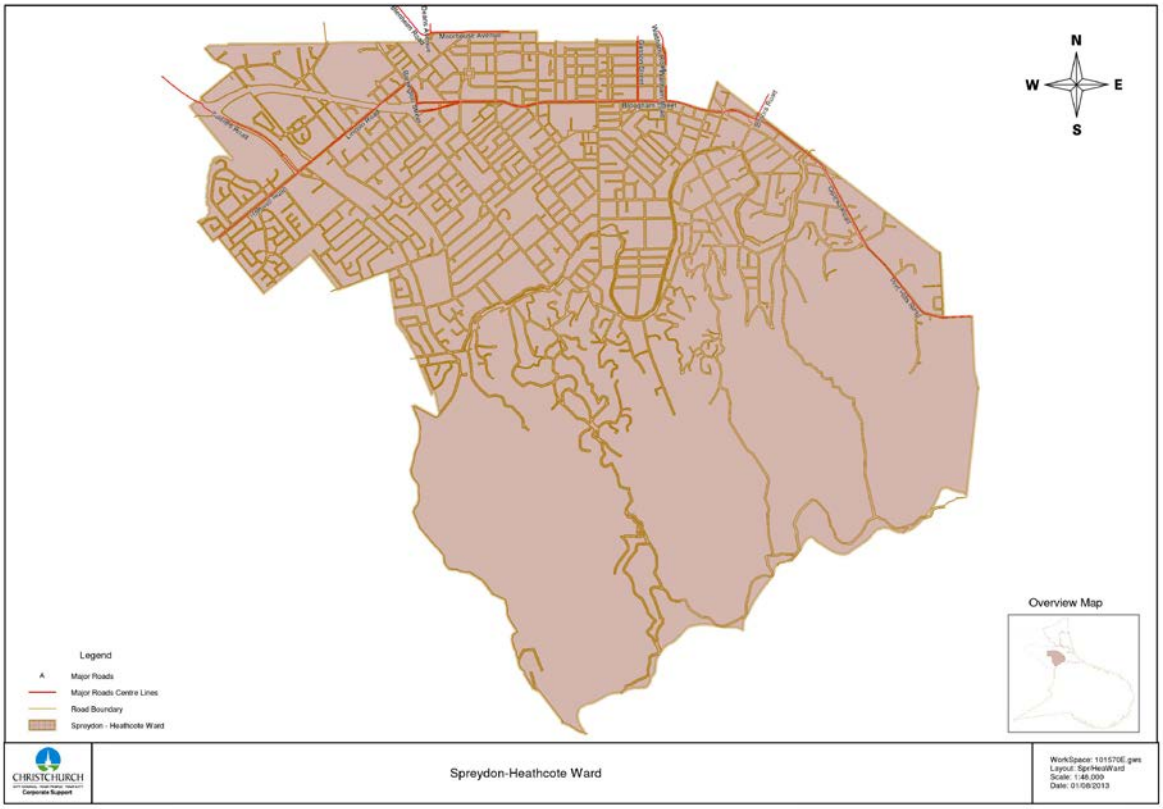
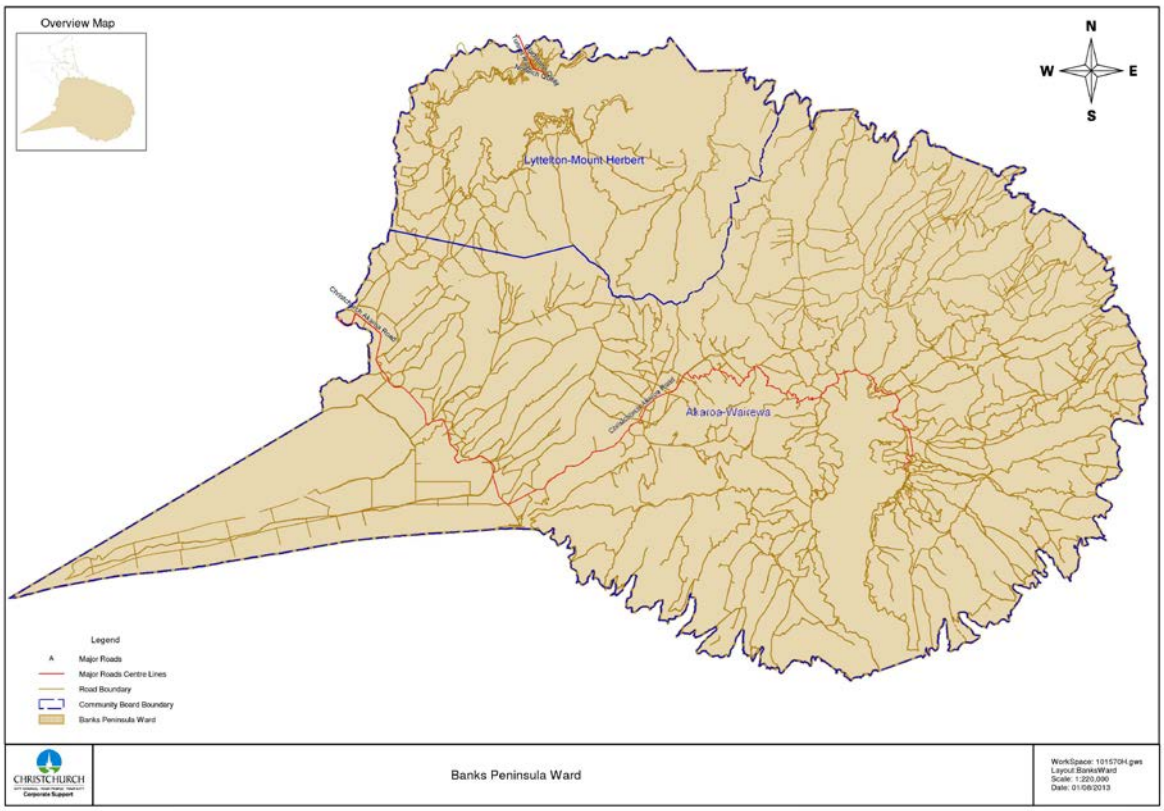
Appendix 4. Ward Maps






N
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Overview Map
Travis Road
Ascot Drive
Pegasus Way
Bridle Path Road
Bridle Path
Legend
Major Roads
Major Roads Centre Lines
Road Boundary
Burwood - Pegasus Ward
CHRISTCHURCH
Corporate Support
Burwood-Pegasus Ward
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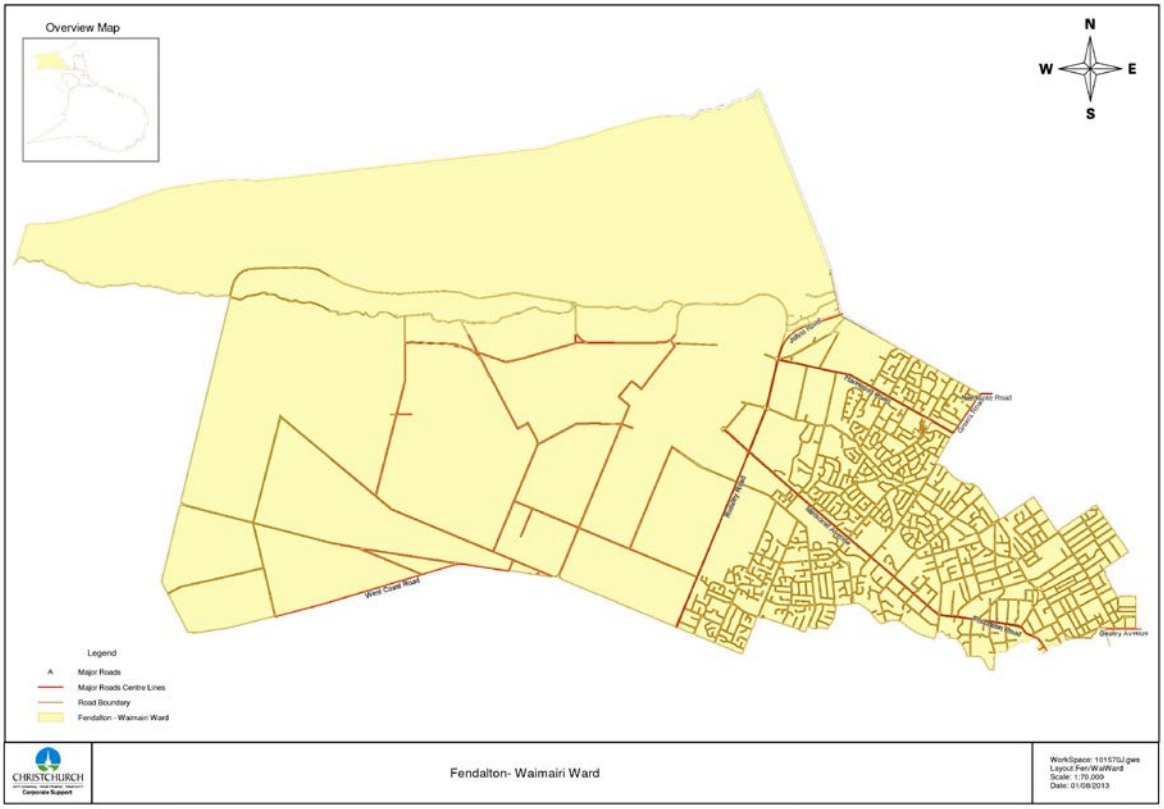
Layout:Bur/PegWard
Scale:1:48,000
Date: 01/08/2013


Overview Map
N
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Legend
Major Roads
Major Roads Centre Lines
Road Boundary
Fendalton - Waimairi Ward
CHRISTCHURCH
Corporate Support
Fendalton- Waimairi Ward
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Layout:Fen/WaiWard
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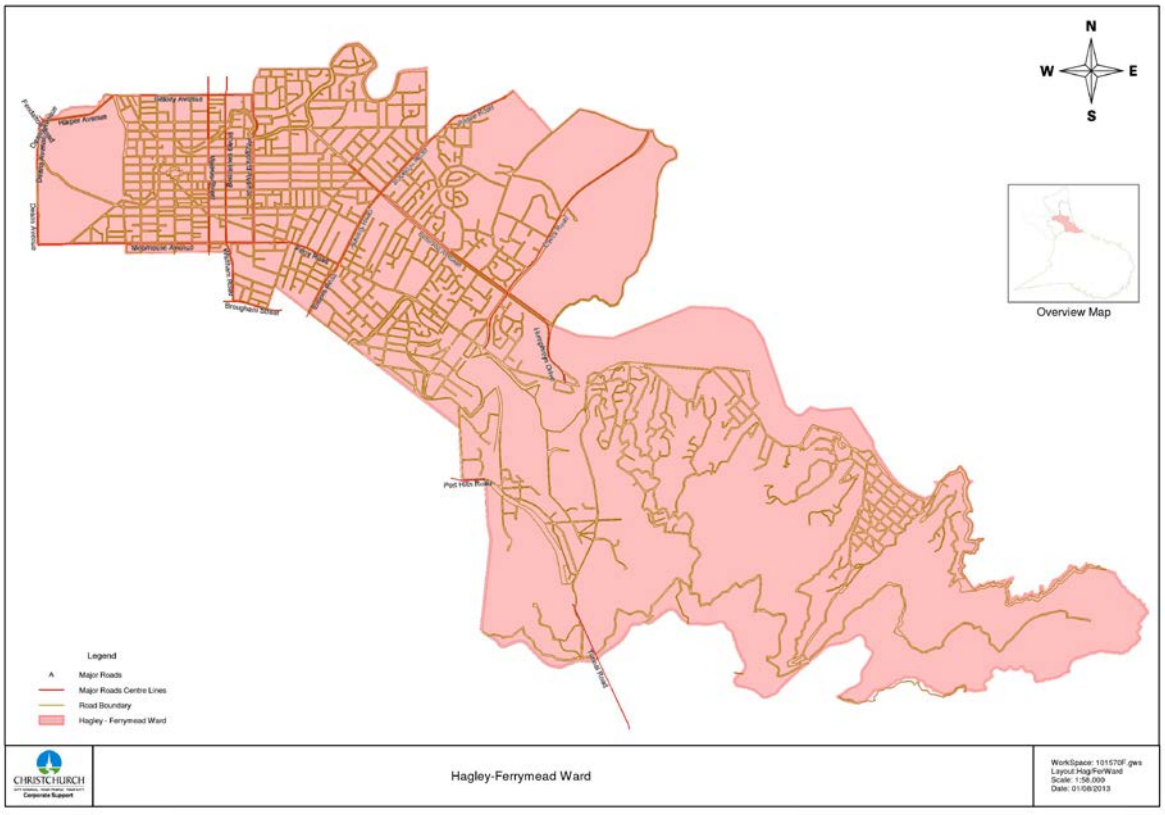
Date: 01/08/2013


N
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E
S
Overview Map
Legend
Major Roads
Major Roads Centre Lines
Road Boundary
Hagley - Ferrymead Ward
CHRISTCHURCH
Corporate Support
Hagley-Ferrymead Ward
WorkSpace: 101570F.gws
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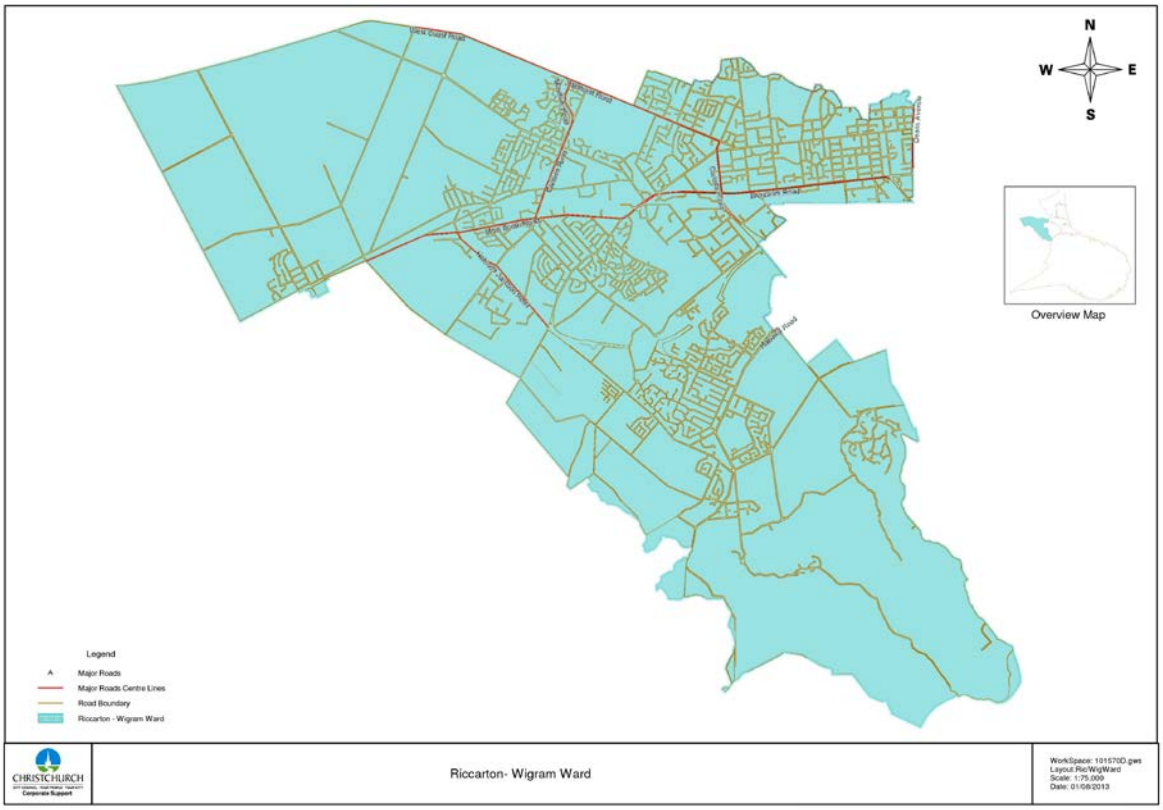
Scale: 1:56,000
Date: 01/08/2013


N
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E
S
Overview Map
Legend
Major Roads
Major Roads Centre Lines
Road Boundary
Riccarton - Wigram Ward
CHRISTCHURCH
Corporate Support
Riccarton- Wigram Ward
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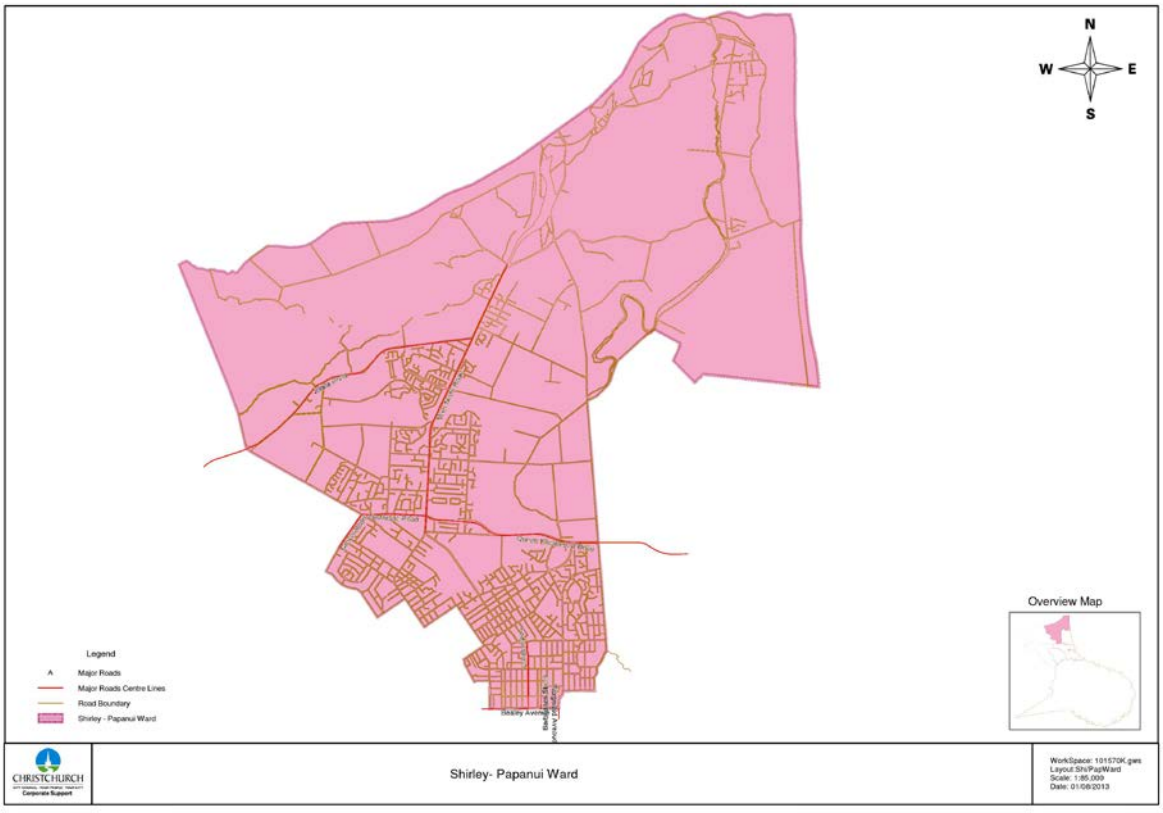
Layout:RicWigWard
Scale: 1:75,000
Date: 01/08/2013


N
W
E
S
Overview Map
Legend
Major Roads
Major Roads Centre Lines
Road Boundary
Shirley - Papanui Ward
CHRISTCHURCH
Corporate Support
Shirley- Papanui Ward
WorkSpace: 101570K.gws
Layout:ShiPapWard
Scale: 1:85,000
Date: 01/08/2013